Archives of
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Official Journal American Congress of Physical Medicine

(Formerly Archives of Physical Therapy)

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28th Annual Session
AMERICAN CONGRESS OF PHYSICAL MEDICINE

August 28, 29, 30, 31, September 1, 1950

HOTEL STATLER BOSTON

VOLUME XXXI JUNE, 1950 NO. 6

American Congress of Physical Medicine

28th Annual

Scientific and Clinical Session

and

Instruction Seminar

August 28, 29, 30, 31, Sept. 1, 1950

Official Headquarters

HOTEL STATLER

Boston, Massachusetts

EXECUTIVE OFFICES

30 NORTH MICHIGAN AVENUE CHICAGO 2, ILLINOIS

INSTRUCTION SEMINAR

In Conjunction with the

28th Annual Scientific and Clinical Session

AMERICAN CONGRESS OF PHYSICAL MEDICINE

August 28, 29, 30 and 31, 1950

HOTEL STATLER — **BOSTON, MASS.**

SCHEDULE

Physicians only may enroll for letter series

MONDAY MORNING — AUGUST 28		
(A) 10:00-10:50 A.M. Neuro-anatomy of the brain and spinal cord Parlor B Corbin	(B) 11:00-11:50 A.M. Neuro-anatomy of the brain and spinal cord Parlor B Corbin	
MONDAY AFTERNOON — AUGUST 28		
(C) 3:00-3:50 P.M. Pathologic physiology of lesions of the brain (types and localizations producing motor disturbances) Parlor B Karnosh	(D) 4:00-4:50 P.M. Pathologic physiology of lesions of the spinal cord (localization of lesions, including poliomyelitis) Parlor B Karnosh	
TUESDAY MORNING — AUGUST 29		
(E) 8:30-9:20 A.M. Pathologic physiology of peripheral nerve lesions, including the neuritides Parlor B De Lorme	(F) 9:30-10:20 A.M. The physiologic effects of heat Parlor B Bierman	
WEDNESDAY MORNING — AUGUST 30		
(G) 8:30-9:20 A.M. Technic of medical writing Parlor B Hammond	(H) 9:30-10:20 A.M. Technic of medical writing Parlor B Hammond	
THURSDAY MORNING — AUGUST 31		
(J) 8:30-9:20 A.M. Physics of muscular action Parlor B Lion	(K) 9:30-10:20 A.M. Physics of muscular action Parlor B Lion	

Physicians and registered physical and occupational therapists may enroll for numbered series

MONDAY MORNING — AUGUST 28		
(1) 10:00-10:50 A.M. Recent hormonal investigations in rheumatoid arthritis Parlor C Polley	(2) 11:00-11:50 A.M. Recent hormonal investigations in rheumatoid arthritis Parlor C Polley	
MONDAY AFTERNOON — AUGUST 28		
(3) 3:00-3:50 P.M. Physical Medicine in rheumatoid arthritis, in the light of the new treatment Parlor C Clark	(4) 4:00-4:50 P.M. The clinical use and dangers of microwave Parlor C Rae	
TUESDAY MORNING — AUGUST 29		
(5) 8:30-9:20 A.M. Analysis of pathologic gaits, and gait training Parlor C Deaver	(6) 9:30-10:20 A.M. Resistive exercises in treatment of poliomyelitis Parlor C Schram	
WEDNESDAY MORNING — AUGUST 30		
(7) 8:30-9:20 A.M. Useful mechanical devices used in Physical Medicine and Rehabilitation Parlor C Russek	(8) 9:30-10:20 A.M. Exercise in the treatment of asthma Parlor C Baker	
THURSDAY MORNING — AUGUST 31		
(9) 8:30-9:20 A.M. Indications for orthopedic reconstruction in poliomyelitis Parlor C Green	(10) 9:30-10:20 A.M. Disabilities of the shoulder Parlor C Kottke	

Note: The Committee on Education of the American Congress of Physical Medicine is in charge of the instruction seminar. It is purposely planned to limit the subjects in any year to a few topics in order to devote enough time to these subjects to give those attending a good review, both from the standpoint of basic knowledge and from the clinical standpoint. Certain groups of these subjects will be repeated every three to five years.

Courses will be offered in two separate groups: One group of ten courses will be offered on basic subjects and this group will be open only to physicians. A second group of ten courses will present more general and clinical subjects. Physicians and therapists may register for the second group of courses. Only those therapists registered with the American Registry of Physical Therapy Technicians or the American Occupational Therapy Association will be permitted to enroll for the instruction courses. The charge for a single lecture is $2.00, for a full schedule of ten lectures, $15.00.

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AMERICAN CONGRESS OF PHYSICAL MEDICINE

30 North Michigan Avenue — **Chicago 2, Illinois**

SECTION ON

PHYSICAL MEDICINE AND REHABILITATION
AMERICAN MEDICAL ASSOCIATION

Meets in Hall 1, Masonic Temple
SAN FRANCISCO, CALIFORNIA
June 28, 29 and 30, 1950

OFFICERS OF SESSION

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WEDNESDAY, JUNE 28th: 2 p.m.

Practical Aids in the Rehabilitation of the Hemiplegic. LEONARD J. YAMSHON, College of Medical Evangelists, Los Angeles, California.

Application of Muscle Physiology to Therapeutic Exercise. DONALD J. ERICKSON and KHALIL G. WAKIM, The Mayo Clinic, Rochester, Minnesota.

Comprehensive Physical Medicine for Degenerative Joint Disease. WALTER M. SOLOMON, Western Reserve University Medical School, Cleveland, Ohio.

Place of Trihexyphenidyl and Mephenesin in Spastic Disorders. WARD SCHULTZ, (by invitation) and ABRAHAM EFFRON, New York University College of Medicine, New York, New York.

The Community Rehabilitation Center and the General Practitioner. ARTHUR C. JONES, University of Oregon Medical School, Portland, Oregon.

Medical Physics, Physical Medicine and Rehabilitation. WALTER J. ZEITER; SHELBY G. GAMBLE, and OTTO GLASSER, Ph.D., (by invitation), Cleveland Clinic Foundation, Cleveland Ohio.

A Study of the Adjustment of 500 Persons Over 16 Years of Age with Disabilities Resulting from Poliomyelitis. GEORGE G. DEAVER, New York University College of Medicine New York, New York.

THURSDAY, JUNE 29th: 2 p.m.

Election of Officers.

Chairman's Address:

The Scope and Future of Physical Medicine and Rehabilitation. FRANK H. KRUSEN, The Mayo Clinic, Rochester, Minnesota.

Physical Medicine and Rehabilitation in Medical Education. HOWARD A. RUSK, New York University College of Medicine, New York, New York.

Retraining Patients with Brain Damage. JOE R. BROWN, The Mayo Clinic, Rochester, Minnesota.

Amputee Rehabilitation. THOMAS J. CANTY, Commander, MC, U. S. Navy, U. S. Naval Hospital, Mare Island, Vallejo, California.

Intermittent Treatment of Poliomyelitis with Progressive Resistance Exercise. SEDGWICK MEAD, Washington University School of Medicine, St. Louis, Missouri.

The Concept of 'Acceptance' in Physical Rehabilitation. MORRIS GRAYSON, New York University College of Medicine, New York, New York.

FRIDAY, JUNE 30th: 2 p.m.

Symposium on Physical Medicine and Rehabilitation for Paraplegics.

Urological Aspects of Rehabilitation in Spinal Cord Injuries. ERNEST BORS, (by invitation), Birmingham V. A. Hospital, Van Nuys, California.

Neurosurgery in the Rehabilitation of Paraplegics. JOHN D. FRENCH, (by invitation), Birmingham V. A. Hospital, Van Nuys, California.

Reconstructive Surgery in Spinal Cord Injuries. A. ESTIN COMARR, (by invitation), Birmingham V. A. Hospital, Van Nuys, California.

Physical Treatment and Rehabilitation of the Paraplegic Patient. HAROLD DINKEN, University of Colorado, Denver, Colorado.

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Volume XXXI No. 6

ARCHIVES OF PHYSICAL MEDICINE
(Formerly Archives of Physical Therapy)
30 North Michigan Avenue, Chicago 2, Illinois

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EDITOR OF THE MONTH

FRED B. MOOR, M.D.
Los Angeles, Calif.

Printed in U.S.A.

PHYSICAL MEDICINE **

The following services are approved by the Council on Medical Education and Hospitals of the American Medical Association and the American Board of Physical Medicine and Rehabilitation. Residencies in this specialty have been approved without specifying the number of years for which they are accredited. The Board will give appropriate credit for training in these hospitals on an individual basis.

Hospitals, 42 Assistant Residencies and Residencies, 55

Name of Hospital	Location	Chief of Service	Inpatients Treated	Number of Treatments	Asst. Res. & Residencies Offered §	Beginning of Service (1950)	Beginning Stipend (Month)
United States Army							
Letterman General Hospital★	San Francisco	A. E. White	21,861	185,112	2	1/1, 7/1	n
†Fitzsimons General Hospital★	Denver	H. B. Luscombe	21,090	281,585	4		n
Army Medical Center★	Washington, D. C.	E. M. Smith	8,676	134,137	6	7/1	n
Veterans Administration							
†Veterans Admin. Hospital ¹	Ft. Logan, Colo.	F. J. Fricke	4,610	58,879	1		n
Veterans Admin. Hospital	Chamblee, Ga.	G. D. Williams	4,923	39,181	1	7/1	n
Veterans Admin. Hospital	Hines, Ill.	L. B. Newman	26,052	472,960	2	1/1, 7/1	n
Veterans Admin. Hospital	New Orleans	S. Wimbish	1,107	49,816	1	7/1	n
Veterans Admin. Hospital ¹	Framingham, Mass.	F. Friedland	9,000	54,000	2	7/1	n
Veterans Admin. Hospital ¹	Jefferson Bks., Mo.	S. Mead	4,046	53,920	2	7/1	n
†Veterans Admin. Hospital ¹	New York City	K. Harpuder	10,613	279,817	3	1/1, 7/1	n
Veterans Admin. Hospital ¹	Cleveland	H. T. Zankel	2,452	106,000	2	7/1	n
†Veterans Admin. Hospital	Aspinwall, Pa.	S. Machover	1,993	62,792	1	7/1	n
†Veterans Admin. Hospital	Portland, Ore.	E. W. Fowlks	4,395	96,766	1	1/1, 7/1	n
Southern							
Los Angeles County Hospital★¹	Los Angeles	O. L. Huddleston		133,694	1	Varies	$165.00
White Memorial Hospital★	Los Angeles	F. B. Moor	33,606				120.00
Stanford University Hospitals★¹	San Francisco	W. H. Northway		6,823		7/1	50.00
University of Colorado Medical Center							
Colorado General Hospital★¹	Denver	H. L. Dinken	3,323	25,988	1	7/1	75.00
†Emory University Hospital★	Emory Univ., Ga.	R. L. Bennett	9,548	20,266	1	7/1	50.00
†Georgia Warm Springs Foundation	Warm Springs, Ga.		889	1,108	2		
Cook County Hospital★¹	Chicago	D. Kobak	3,357	23,282		1/1, 7/1	
Michael Reese Hospital★¹	Chicago	C. O. Molander	1,607	19,463	1	Varies	25.00
Northwestern University Medical School	Chicago		13,284	34,813			
University of Kansas Medical Center★	Kansas City, Kan.	D. L. Rose	11,684	31,039	1	7/1	100.00
†Massachusetts General Hospital★	Boston						
University of Minnesota Hospitals★¹	Minneapolis	M. Knapp	15,391	21,885	4		165.00
Mayo Foundation	Rochester, Minn.	F. H. Krusen			9	Varies	92.50
Barnes Hospitals★	St. Louis		820	10,951		7/1	25.00
†Bellevue Hospital, Div. III—							
New York University★	New York City						
Goldwater Memorial Hospital★¹	New York City		2,799	124,357			
Hospital for Joint Diseases★¹	New York City	J. Weiss	76,070	93,036	1	7/1	40.00
Hospital for Special Surgery	New York City	K. G. Hansson		41,111			
Montefiore Hosp. for Chronic Diseases★¹	New York City	K. Harpuder					
Mount Sinai Hospital★	New York City	W. Bierman				7/1	50.00
New York City Hospitals★¹	New York City	F. K. Safford, Jr.	955	26,418			
†Presbyterian Hospital ★¹	New York City	W. B. Snow	70,405	191,021	2	1/1	41.66
St. Luke's Hospital★	New York City	R. Muller	1,202	126,904	1	7/1	50.00
†Rehabilitation Hospital¹	W. Haverstraw, N. Y.	M. Huberman	322	291,115	1		200.00
Cleveland Clinic Hospital¹	Cleveland	S. Gamble	17,885	17,884	1	7/1	125.00
Hospital of the Univ. of Pennsylvania★¹	Philadelphia	G. M. Piersol	1,396	15,575	1	Varies	100.00
Philadelphia General Hospital★¹	Philadelphia		2,073	21,769			
Medical College of Virginia, Hosp. Div.★	Richmond, Va.	V. A. Hellebrandt	3,787	34,009			
State of Wisconsin General Hospitals★¹	Madison, Wis.	H. D. Bouman	3,787	45,840			

The star (★) indicates hospitals approved for training interns.
The dagger (†) indicates temporary approval.
¹ Residencies open to women.
§ Includes Fellowships.
n Salary established by government pay tables.

** Reprinted in part J. A. M. A. 142:1195 (April 15) 1950

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WESTERN SECTION
AMERICAN CONGRESS OF PHYSICAL MEDICINE
LETTERMAN GENERAL HOSPITAL
PHYSICAL MEDICINE CONFERENCE ROOM
SAN FRANCISCO

Sunday, June 25, 1950

Frances Baker, M.D., Chairman
Clarence W. Dail, M.D., Secretary

9:30 Registration.

10:00 Principles of Muscle Dynamics: H. J. Ralston, Ph.D.

Principles of Muscular Action: Verne T. Inman, M.D.

11:30 Business Meeting.

Consideration of future plans.

12:00 Luncheon.

2:00 to 4:00 —

Diagnostic Methods in Neuromuscular Disease: Col. A. E. White.

1. Use of the Electromyograph — Evaluation of Results.
2. Use of the Neuro-Dermometer — Evaluation of Results.

Patients and material to be presented by Col. White and staff.

Discussion: James C. Golseth, M.D.
S. M. Dorinson, M.D.
Verne T. Inman, M.D.

Although definite plans cannot be made at this time it is expected that certain leaders in physical medicine and rehabilitation will be present and will participate in the program. It should be noted that the American Rheumatism Association and the American Medical Association meet just before and after this program.

SUMMER VACATION RELIEF

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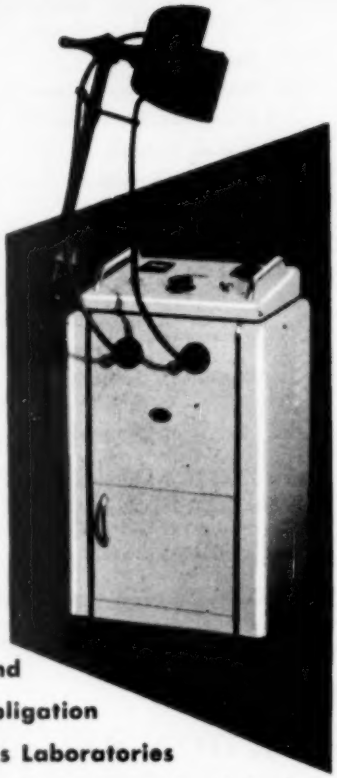

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THE LATENT PERIOD OF MUSCULAR CONTRACTION*

ALEXANDER SANDOW, Ph.D.

NEW YORK

When a muscle is activated by a stimulus directly applied to its fibers, a short time interval passes before the muscle begins to develop tension. This interval is the mechanical latent period — or, briefly, the latent period (LP) — of the muscle's response. In frog skeletal muscle the LP[1] has a duration of about three milliseconds. So short is this time lapse that until recently a great part of the research on this phenomenon — extending back almost a century — dealt merely with the question of its existence, for many investigators believed that the LP was an artefact due to inertia in response of the recording apparatus.

This question was essentially settled in 1922 by Rauh[1] who studied the LP by means of an extremely light and sensitive optical myograph. Not only did he validate the view that the LP really exists, but, more important, he found that the stimulated muscle actually relaxes very slightly during the latter half of the LP. Obviously, the latent period cannot be an artefact, since the muscle must first pass through this initial relaxation, or elongation stage, before the onset of its characteristic tension development. Rauh's discovery, however, was generally neglected, and the old controversy concerning the existence of the LP continued unabated.

About ten years ago I began my own research on the LP and decided that it would be fruitful to apply modern electronic methods to this problem — and to the recording of contraction in general. The resultant studies have afforded ample verification of Rauh's original observation. But, more significantly, they have shown that the LP — short as it is and minute as is its relaxation phase — may be used as a sort of "peephole" through which one may look into the whole of a muscle response and gain some insight into the fundamental mechanisms of muscular behavior. The development of our research has led to results[2] pointing in two directions: one, toward the elucidation of mechanochemical coupling, that is, the means by which chemical potential energy is transferred to the contractile units for conversion into tension and work; the other, toward the clarification of excitation-contraction coupling, that is, the mechanism by which excitation processes in the muscle membrane may be linked to the mechanical activation of the inner contractile material.

A block diagram of our electron-myographic apparatus is presented in figure 1. A muscle, *M*, generally the frog sartorius, is supported at its lower (pelvic) end inside a muscle chamber, *C*, which, for temperature control, is immersed in a constant temperature water bath. The upper (tibial) end of the muscle is connected under a few grams resting tension to the stylus, *S*, of a piezoelectric pick-up, *P*, which is a common type of phonograph crystal pick-up. When the muscle is stimulated (*St*, stimulator) by delivery of an electric shock through the electrodes placed at the muscle ends, the resultant muscular tension changes are converted by the pick-up into a corresponding electric pulse,

* From the Department of Biology, Washington Square College of Arts Science, New York University. This research has been supported by grants from the Penrose Fund of the American Philosophical Society, and it is now going on under contract between the Office of Naval Research and New York University. Some of the experiments were done in collaboration with Dr. A. G. Karczmar and others with Mr. A. J. Kahn.

* Read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine, Cincinnati, Sept. 8, 1949.

1. Rauh, F.: Ztschr. Biol. **76**:25, 1922.

2. (*a*) Sandow, A.: J. Cell. & Comp. Physiol. **24**:221, 1944; (*b*) Ann. New York Acad. Sc. **46** (3):152, 1945. (*c*) Year Book, Am. Philosophical Soc. 182, 1946. (*d*) Ann. New York Acad. Sc. **47** (6):895, 1947. (*e*) Sandow, A., and Kahn, A. J., Fed. Proc. **8**:277, 1949.

and this, after passage through the amplifier, *A*, is used to deflect vertically the beam of a cathode ray tube, *CRT*. Thus the tension changes of the muscle are finally made visually evident in the movement of the cathode ray beam,

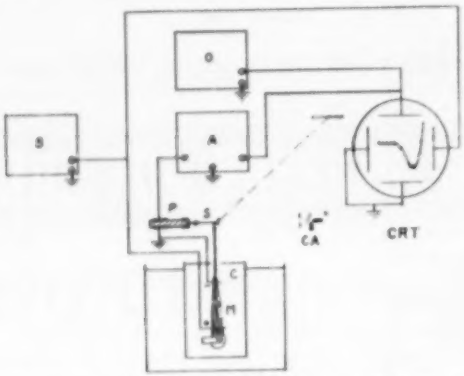

Fig. 1. — Block diagram of the piezoelectric, cathode ray oscillographic myograph. *C*, muscle chamber immersed in a constant temperature water bath; *M*, frog sartorius muscle connected by a fine metal chain to the stylus, *S*, of a crystal phonograph pickup, *P*; *St*, Stimulator; *A*, amplifier; *O*, oscillator; *CRT*, cathode ray tube; *CA*, carbon arc which produces a light beam for conventional isometric optical myographic recording of initial and peak twitch muscle tensions.

which may be photographed for obtaining permanent records. Each response is impressed on a single sweep of the beam which is initiated by the stimulus, and which is modulated by a sinusoidal wave at a frequency of 10,000 cycles a second, produced by the oscillator, *O*, for calibration of the horizontal time axis. Included also is the tension beam, originating in the carbon arc, *CA*, which permits a conventional optical myographic recording of the initial and peak tensions of the muscle.

This apparatus has been developed so that all phases of a muscular response can be recorded oscillographically. However, we shall be concerned here only with certain studies of the tension alterations of the latent period. A typical LP record is illustrated in figure 2. The beginning of the record at the extreme left is coincident with the instant of stimulation, and this is followed by a mechanically quiescent period of about 1.2 milliseconds. There then follows the sigmoid-shaped latency relaxation (LR), lasting about 2.0 milliseconds, which, after an abrupt termination, passes over into the very beginning of tension development. The inset of the illustration gives the symbols of the LP variables that are generally measured. We shall here be concerned with the following: L_R, measuring the interval from the instant of stimulation to the initiation of the latency relaxation; *L*, which measures the interval from the moment of stimulation to the onset of tension, and R, which measures the depth of the latency relaxation. Also included at the upper right corner of this photograph is the optically registered position of the tension beam, which permits recording the initial and peak-developed tensions of the muscle.

From the preceding it is evident that the LP has a duration of about 3.2 milliseconds. This interval is measurable with a precision of ± 0.03 milliseconds. Under normal conditions *R* represents a negative tension change of about 20 mg., which, taking into account the stiffness of our stylus lever, corresponds to a muscle length increase of about 0.1 micron, and these changes in

R can be recorded with an error of ±5-10 per cent. In effect the apparatus acts as an electronic lever, and, since an actual LR length increase of 0.1 micron, may be represented on the cathode ray screen by a deflection of about

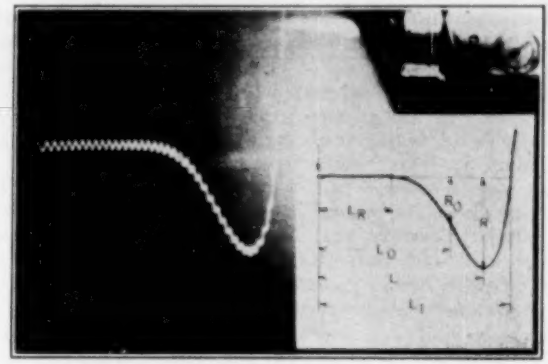

Fig. 2. — Typical photographic record of latent period mechanical changes. Mechanical changes, modulated by a 10,000 cycles per second timing wave, given at left. The beginning of this record at extreme left is coincident with the instant of stimulation. See text for further details. Upper band at upper right corner indicates the initial tension of the muscle; lower band registers the peak twitch tension. Inset diagram gives all parameters measured, of which the relevant ones here are: L_R, the time from instant of stimulation to beginning of latency relaxation; L, a similar time to beginning of positive tension development (i. e., the usual latent period of the mechanical response); R, the depth of the latency relaxation.

10 cm., the length-magnification factor of this lever is 1,000,000 ×. Ordinary optical myographs operate with a magnification factor, at most, of about 500 ×. Hence the electronic myograph is 2,000 times as sensitive as the optical.

A considerable amount of work in my own laboratory has demonstrated directly that the LR is not an artefact.[3] Further evidence that this is so, and that, therefore, the LR represents some fundamental muscular response, is indicated in the recent results that a transient increase in transparency[4] and, evidently, a rapid outburst of heat[5] occur in a stimulated muscle concomitant with the LR. These various findings — and others might be mentioned,[6] — clearly prove that during the latter part of the latent period, i. e., during the LR, the contractile material is undergoing some radical alteration that is concerned with transforming it from a state of rest to a state of contraction.

It should be emphasized that neither our own experiments nor those of others enable us to conclude definitely just what this transformation is. I should like to discuss, however, some of my own research that sheds some light on this difficult problem.

As a necessary preliminary to this discussion it is desirable to outline some of the current views concerning possible mechanisms of contraction as derived from studies of muscle extractives. The essential contractile system seems to be composed of two principal components. The first of these, the contractile material, is the fibrous protein, actomyosin,[7] which is found in muscle as bundles of filaments with their long axes parallel to that of

3. Sandow, A.: Fed. Proc. 7 (1):107, 1948. Footnote 2a and *d*.
4. Hill, D. K.: J. Physiol. **108**:282, 1949.
5. Hill, A. V.: Proc. Roy. Soc. Biol. **136**:242, 1949.
6. Dubuisson, M.: Experientia 3:213, 1947.
7. (*a*) Szent-Györgyi, A.: Chemistry of Muscular Contraction, New York, Academic Press, Inc., 1947. (*b*) Sandow, A.: Ann. Rev. Physiol. **11**:297, 1949.

the muscle fiber. The second component is the nucleotide adenosinetriphosphate, which evidently serves as the direct source of energy for the contractile material. A notable advance as to the possible mechanism by which these react in a contracting muscle was made by Engelhardt,[8] who found that the myosin part of actomyosin (or some other protein strongly adsorbed on the myosin) is an enzyme, specifically catalyzing the dephosphorylation of the terminal phosphate group of adenosinetriphosphate and thus releasing about 12,000 small calories for each mole of phosphate split off. It is generally presumed that this enzymic reaction, i. e., of myosin acting as adenosinetriphosphatase, is the means by which actomyosin is energized for its contractile activity. This view is strengthened by the fact that actomyosin fibers, spun from a solution of this material after extraction from muscle, react mechanically in the process of interacting with adenosinetriphosphate. Thus Engelhardt[8] observed that threads of the contractile material relax in the presence of adenosinetriphosphate while Szent-Gyorgyi,[9] working under rather different conditions, found that actomyosin fibers contract under the influence of this substance.

It may seem confusing that in the presence of adenosinetriphosphate actomyosin, depending on conditions, will either contract or relax. But it must be remembered that in a cycle of activity a muscle also contracts and relaxes, and thus any explanation of a muscle response must account for not only its capacity to develop tension but also its ability to relax, and, indeed, to do so in its precontractile latency relaxation as well as in its postcontractile relaxation. The point that should be emphasized here is that actomyosin and adenosinetriphosphate, which few doubt are key substances actually involved in the mechanical activity of live muscle, comprise a mechanochemical system — i. e., their interaction, generally speaking, involves a chemical decomposition of adenosinetriphosphate with associated energy liberation and a mechanical alteration of actomyosin. Thus the problem of muscular contraction, viewed from the standpoint of the results of study of muscle extracts, becomes a problem of the mechanochemistry of the actomyosin-adenosinetriphosphate contractile system (Engelhardt[8b]); and within this context looms large the adenosinetriphosphatase action of myosin. Put another way, it may be stated that the mechanochemical problem of muscular contraction is rooted in the property that myosin is a contractile enzyme.

Despite the attractiveness of the mechanochemical findings and their apparent pertinence to the actual mechanism of contraction, it has yet to be shown how these results, if at all, apply to the physiologic behavior of muscle. My long interest in the latent period stems from the view that its LR signifies some feature of the initial response to a stimulus of the actomyosin-adenosinetriphosphate system, and that a study of this phenomenon might therefore help one to understand the fundamental process by which muscle is energized for contractile activity. I will now discuss some experimental results bearing on this problem.

Investigations[20-4] have been made of the effect of hydrogen ion concentration on the latent period. The pH variable is of interest because in vitro studies prove that myosin-adenosinetriphatase decomposes its substrate more rapidly the higher the pH. Hence, if the action of this enzyme system occurs during the latent period in connection with the activation of the contractile material for tension development, one should expect that increasing the pH of a muscle, and therefore accelerating the rate of breakdown of adenosinetriphosphate, would cause a more rapid onset of tension which would be re-

8. (a) Engelhardt, W. A.: Yale J. Biol. & Med. 15:21, 1942; (b) Advances in Enzymol. 6:147, 1946.

flected in a shorter latent period. Figure 3 shows that the expected variation in the latency time paramenters does occur. In these experiments a frog sartorius muscle was adjusted to a series of different pH's by equilibration with a corresponding series of bicarbonate buffers. It is clear that the higher the pH, the smaller are the latencies, and this result is consistent with the view that,

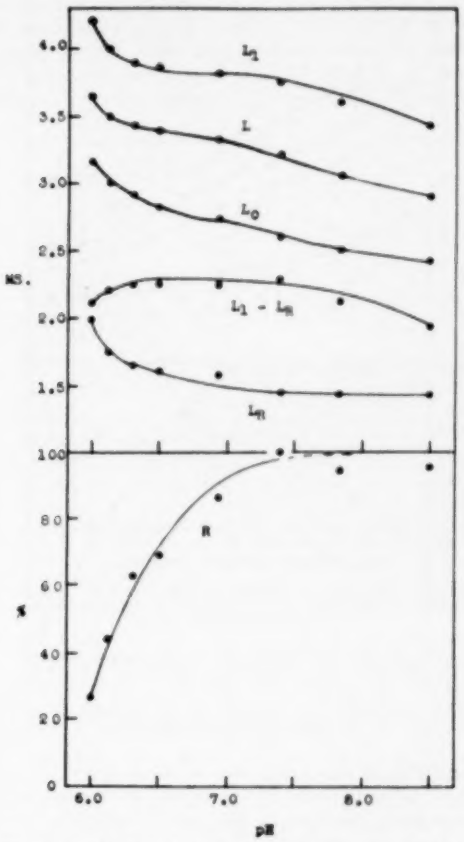

Fig. 3. — The effect of pH on the latency parameters (which are defined in figure 2). Times are given in milliseconds, MS. Note that, although the variation in R is not discussed in the text, this parameter increases with increase in pH in the range from 6.8 to 7.5.

at least during the latent period, the myosin-adenosinetriphosphatase goes into action as a preliminary to the subsequent activation of tension output.

If the hydroylsis of adenosinetriphosphate is taking place during the latent period, then it becomes important to search for independent proof that the specific enzyme for this reaction, myosin, is involved in the process. Certain experimental effects of temperature on the latency behavior suggest that this is so. Figure 4 presents the variations in the latent period parameters as a function of temperature over the range from 10 to 40 C. The general decrease in the time variables with increase in temperature probably

reflects the general increase in rate of the chemical reactions — i. e., especially the dephosphorylation of adenosinetriphosphate — responsible for initiating the contractile response. But I wish especially to call attention to the peculiar behavior of *R*, the depth of the latency relaxation. Note that as

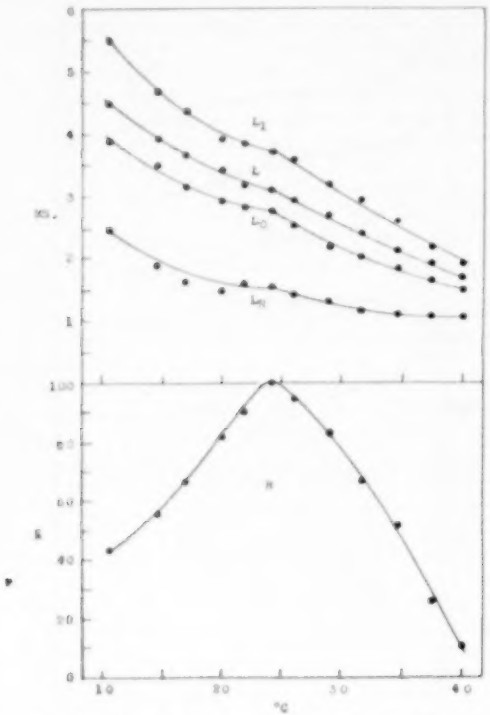

Fig. 4. — The effect of temperature on the latency parameters. Symbols as previously defined.

the temperature rises *R* increases to a maximum at about 25 C. and then falls. This variation in *R* is reminiscent of the behavior of many enzymes, for they also have their maximum effect at an optimum temperature which lies at some midpoint of the range of temperature in which they are active. This leads one to infer that the latency relaxation is a mechanical reflection of some activity of an enzyme, probably myosin-adenosinetriphosphatase. It may seem odd to associate a mechanical change with enzyme action, but this is the very nub of our approach to the study of contraction, since it seems that myosin is a contractile enzyme.

Further evidence that the activity of myosin is associated with the formation of the latency relaxation is found in another series of temperature studies concerned with the heat inactivation of the LR. In these experiments, a muscle is first tested for its latency response at a temperature of 25 C., which is optimum for *R*. It is then put into a Ringer solution bath at a relatively high temperature — say 38.5 C. and kept there for ten minutes. When the muscle is restored to its original temperature of 25 C. it is found that the

depth of R is considerably and irreversibly reduced, and this decrease in R is called the irreversible inactivation of the LR. If this procedure is repeated a number of times, each exposure to the high temperature causes further inactivation of the LR until finally the muscle becomes completely irresponsive. Figure 5 illustrates the results of such tests performed at three different temperatures. It can be seen that at each temperature, the degree of inactivation of the LR — i. e., the decrease in R — increases as a fairly linear function of the number of ten minute inactivation periods; and it is further obvious that the higher the temperature the greater is the rate of inactivation as measured by the average slope of each inactivation curve. If now the rate of inactivation at each temperature studied is plotted against the temperature, the graph shown in figure

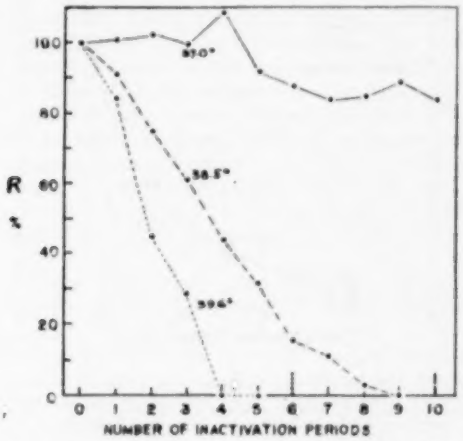

Fig. 5. — The effect on R of exposure to a series of ten minute high temperature inactivation periods. Temperature of each series given in degrees centigrade.

6 is obtained. It should be noticed that at, and below, 37 C. no irreversible inactivation occurs and that above this temperature the inactivation rate increases, first slowly and then extremely rapidly, especially in the narrow range at about 40 C. The temperature coefficient of this process, expressed as a Q_{10} value is, at about 38 to 39 C., of the order of several thousand. It is, finally, noteworthy that at about 41 C. the rate of irreversible inactivation is so great that an exposure of only a few minutes is enough to suppress the LR completely, and, for that matter, the whole of the muscular response.

Now, these results are significant, for they are almost exactly parallel to Mirsky's findings[9] of the heat denaturation of myosin extracted from frog muscle. He found that denaturation begins at 37.5 C., increases very rapidly over the next few degrees, with a Q_{10} of about 1,000 at 38.5 C., and is almost instantaneous at 41 C. These thermal features of the inactivation of the LR and the denaturation of myosin are so similar that it is reasonable to assume that the LR is determined by some action of myosin in the intact muscle.

Summarizing our various pH and temperature studies, it seems to be indicated that during the latent period (1) adenosinetriphosphate is being split; (2) an enzyme is involved, and (3) myosin is involved. We therefore infer

9. Mirsky, A. E.: Proc. Soc. Biol. & Med. 37:167, 1937.

that the myosin-adenosinetriphosphatase enzyme system is active during the latent period. From this one may hypothesize that when a muscle is stimulated some consequence of the excitation process permits myosin-adenosine-

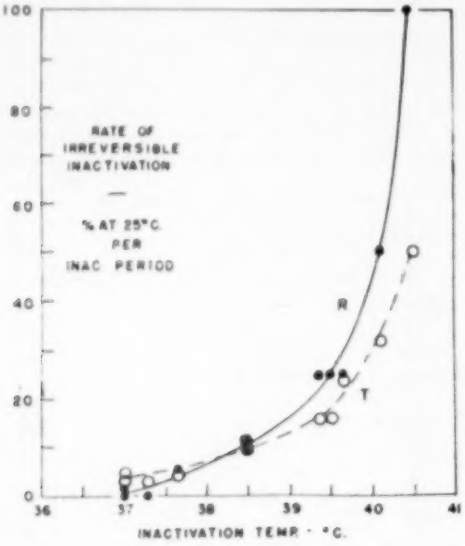

Fig. 6. — The rate of inactivation of R as a function of temperature. Also included is the inactivation rate of the peak twitch tension, T, which, although not discussed in the text, may be noted to be roughly parallel to the changes in R.

triphosphatase and its substrate, adenosinetriphosphate to react, and they do so, or at least begin to do so, during the latent period. What the latency relaxation represents in this reaction, we do not know; but we have suggested that it may be a mechanical sign of the formation of an enzyme-

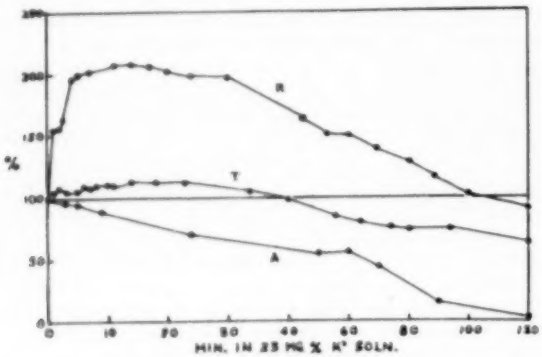

Fig. 7. — The progressive effects of Ringer's solution containing 23 mg. of potassium ions per hundred cubic centimeters (about three times normal potassium concentration) on R, the depth of the latency relaxation; T, the peak twitch tension, and A, the magnitude of the action potential. The ordinates give values of the various responses relative to those of the muscle in normal Ringer's solution. Note change in the time scale at the 60 minute point.

substrate complex between myosin and adenosinetriphosphate. At any rate, as the reaction between adenosinetriphosphate and myosin goes on, adenosinetriphosphate is dephosphorylated and the energy thus released is immediately taken up by the actomyosin, which is thus made able to contract.

It will be noted that in the preceding description of our hypothesis of mechanochemical coupling in the living muscle, elements only of the contractile system have been mentioned. The question that now arises is: What is the mechanism by which the contractile system is coupled to the excitatory events of the muscle fiber membrane which are set in motion as an immediate consequence of stimulation? This is one of the most difficult problems in muscle physiology, and very little research has been done on it (see, however, recent papers by Kuffler[10] and Hill[10]).

Rather unexpectedly, some current experiments dealing with the effect of the potassium ion on the LR tend to elucidate this problem.[11] A brief preliminary discussion of some of the results will be given here. In these studies the test muscle is first equilibrated in Ringer's solution and its normal twitch behavior following maximal stimulation is recorded. The muscle is then immersed in Ringer's solution enriched with potassium ions by addition of a suitable quantity of potassium chloride, and as it soaks in this experimental solution, its behavior is registered at appropriate intervals for two hours. In the experiments to be reported here, all shocks applied to the potassium-treated muscle are of maximal strength as determined for the normal tissue.

Figure 7 presents some results obtained with a solution consisting of 23.0 mg. of potassium in 100 cc. of Ringer's solution, which contains about three times the normal concentration of potassium. It will be noted that within the first five minutes, R, the depth of the LR, increases to about 200 per cent of normal and, after maintaining this level for about thirty minutes, it then falls so that at the end of the two hour period it has returned to about normal. The peak-twitch tension output, T, shows a roughly similar series of changes, although the greatest increase is only about 12 per cent greater than normal. As for the magnitude of the action potential, represented by A, this, instead of increasing at first, as do R and T, starts immediately to decrease and it is practically obliterated at the end of two hours.

These results are very suggestive. In the first place, the dissimilarity in the alterations of the action potential from those exhibited by the mechanical features of the response, represented by R and T, definitely indicates that it is not the action potential, at least as commonly supposed, that activates the muscular contractile system. Kuffler,[10] indeed, has proposed on the basis of his experiments on contractures that it does not seem to be the flow of the local circuits of the action potential that arouses contraction, but rather the depolarization, as such, of the muscle fiber membrane. Our results are in agreement with this view, at least in dissociating the action potential in the sense of its necessarily accompanying local circuits, from the mechanism that triggers the contractile system into mechanical activity. Our present results, however, give no clear indication that the depolarization of the membrane is the key feature of excitation that initiates excitation-contraction coupling. Experiments to test this point are in progress and will be reported elsewhere.

A second point of the potassium experiments is concerned with the great rapidity with which the initial increases in R and T develop. Figure 7 demonstrates that these increases rise to their maxima in a time of the order of

10. Kuffler, S. W.: J. Neurophysiol. 9:367, 1946; Ann. New York Acad. Sc. 47:767, 1947.
11. Footnote deleted on proof.

five minutes, and this interval is so short that it is inconceivable for the potassium ions to have penetrated into the muscle fibers and thus exert its effect directly on the contractile system. A more reasonable explanation is that the potassium directly affects only the excitatory membranes of the muscle cells; these then become modified so that when they are stimulated by a shock they undergo an altered response, and, in consequence of this, the contractile system develops the enhanced outputs in R and T as observed in the results. Thus we account for the changed mechanical behavior immediately after potassium treatment as an indirect effect of potassium on the contractile system mediated by way of the excitation portion of excitation-contraction coupling.

Although our experiments to date do not permit us to draw any certain conclusions concerning the direct effect of the potassium ion on the muscle fiber membrane, an inference is that this ion loosens the binding of calcium in the membrane and general cortical region of the muscle cell.[12] It is known that external treatment of certain cells with potassium does cause an internal release of the calcium ion[13] from the cortical regions. Furthermore, Heilbrunn[14] has presented a general theory of stimulation which is based on the view, supported by considerable evidence, that any excitatory agent exerts its immediate effect by causing a release of calcium ions from the membrane and cortical cell layers. We therefore feel it is reasonable to postulate that the excitatory membranes of our potassium-treated muscles, merely because of this abnormal experimental state, have released some extra calcium ions into the intrafibrillar regions and, furthermore, under the impact of an electric shock, a greater than normal amount of calcium is separated from the membrane. Hence, under these conditions, the intrafibrillar contractile system is activated by an augmented concentration of calcium ions, and thus, as observed in the initial period of our experiments, there results an increase in the muscular mechanical response. (But see Hill.[15])

A particularly attractive feature of this hypothesis is its consistency with the fact that the calcium ion is an especially effective activator for the myosin-adenosinetriphosphatase system. We may therefore suppose that when a muscle is stimulated in the presence of augmented external potassium and this results in a release of calcium ions that is greater than normal there is then an enhanced activation of the contractile enzyme system, which is finally reflected mechanically in the greater values of R and T. Of especial interest is the application of this view in accounting for the increase in R in potassium-treated muscles. It has been previously suggested in this paper that the latency relaxation may be a mechanical sign of the formation of an enzyme-substrate combination between myosin and adenosinetriphosphate. If, in the live muscle, calcium is the activator of myosin-adenosinetriphosphatase, and if, as the preceding discussion suggests, the effect of potassium is to increase the internal calcium, then, under these conditions, we should expect the formation of a greater concentration of the enzyme substrate combination, and this, in turn, should determine the production of a greater depth of the latency relaxation. Since this increase in R is, in fact, observed in the immediate responses of the potassium-treated muscles, this may be taken as evidence supporting the general hypothesis we have presented to explain the immediate effects of potassium.

12. Hober, R.: Physical Chemistry of Cells and Tissues, The Blakiston Co., Philadelphia, 1945, Chapter 18.
13. Mazia, D.: J. Cell. & Comp. Physiol. **10**:291, 1937; Cold Spring Harbor Symposia **8**:195, 1940. Chiercuy, L., and Moser, F.: Physiol. Zool. **13**:212, 1940.
14. Heilbrunn, L.: An Outline of General Physiology, ed. 2, Philadelphia, W. B. Saunders Company, 1943, chap. 37.
15. Hill, A. V.: Proc. Roy. Soc., B. **135**:446, 1948.

What, then is the effect of the potassium ion after it has acted for more than thirty to thirty-five minutes, when the *R* and *T* values are decreasing from their elevated plateaus back to normal? It is possible that during this period the potassium ion has already penetrated into the muscle cell in sufficient quantity to act directly suppressively on the contractile system. It is known that the potassium ion does inhibit the myosin-adenosinetriphosphatase. Another possibility is that through longer action of the potassium ion the membrane becomes impaired because of an excessively great disintegrating effect, generally characteristic of the action of this ion on cells; and, thus, the membrane-excitatory mechanism loses its enhanced power to release calcium ions for activation of the contractile enzyme system. Further experiments are needed to settle this point.

Integrating our various results presented here, we postulate that excitation by a stimulus serves to release calcium from the cortical or membrane regions of the muscle fibers. Probably, the interval from the instant of application of the shock to the beginning of the latency relaxation (measured by *I*, a) represents the period for this to occur. At any rate, we suppose that this process is an essential event in excitation-contraction coupling. The free calcium activates myosin-adenosinetriphosphatase thus permitting this enzyme to form a complex with its substrate, adenosinetriphosphate, which is represented mechanically by the latency relaxation. Once the complex is formed, adenosinetriphosphate is hydrolyzed and the energy so released is immediately taken up by the actomyosin, which then converts this energy into the mechanical output of tension (or work) of the muscle.

It must be emphasized, however, that this hypothesis is the result of a series of interpretations each of which may be seriously questioned. Furthermore, these interpretations are based solely on latent period alterations. It would be better therefore to designate our views of the excitation-coupling and mechanochemical energization processes as working hypotheses. At least, that is how they are being used at present, and, as such, they certainly have the virtue, if no other, of suggesting further lines of research, now being developed in my laboratory, not only on the latency phenomena but also on excitation and the contraction and relaxation periods of the muscular response.

One final comment remains to be made. The research I have reported is concerned with the fundamental mechanisms of excitation and contraction, and nothing I have said bears obviously on any clinical muscular dysfunction. I do not think I need to argue here, however, for the need of fundamental studies of normal muscle as a basis upon which medical application may ultimately be made. Indeed, it would be most interesting and clinically profitable, I believe, to utilize the methods and orientation I have developed in this paper to the problem of various muscular disorders, especially to those of the experimentally induced atrophies. It is our plan, as soon as conditions are favorable, to undertake such research.

THE USE OF ELECTROMYOGRAPHY IN THE DIAGNOSIS OF NEUROMUSCULAR DISORDERS *

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LOS ANGELES

Introduction

Electromyography is now a well recognized clinical procedure, destined to equal electrocardiography in importance. We believe that the electromyograph will be an instrument as valuable to the physiatrist, the neurologist, the neurosurgeon and the orthopedic surgeon as the electrocardiograph is to the internist and the general practitioner. It is a laboratory instrument which will provide information to supplement the clinical findings of the physician responsible for the diagnosis, evaluation and treatment of the patient.

Electromyography has three important services to offer in the management of neuromuscular disorders: (1) differential diagnosis; (2) prognosis; (3) assistance in the treatment. Only the first of these services will be discussed in this article.

It is extremely important to use suitable equipment and proper technics to obtain the information desired from electromyography. Practically all pertinent electromyographic data can be obtained with a single channel electromyograph. Neither the electroencephalograph nor the electrocardiograph is a suitable instrument for the electromyographic examination of patients with suspected lower motor neuron disease. It has been agreed by many authorities in the field of electromyography[1] that the use of the needle electrode technic, combined with a high gain amplifier and a cathode ray oscilloscope, is essential to secure the desired diagnostic information about lower motor neuron diseases. Since determining the presence or absence of lower

* Aided by a grant from the National Foundation for Infantile Paralysis, Inc.

* Read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine, Cincinnati, Sept 10, 1948.

1. (a) Jasper, H. H., and Johnson, R. H.: A Portable Clinical Electromyograph: Report to Associate Committee on Army Medical Research, National Research Council, Canada, from the Montreal Neurological Institute, McGill University, 1945. (b) Bauwens, P.: Electromyography in Clinical Medicine, Brit. J. Phys. Med. 10:75, 1947. (c) Hoeffer, P. F. A.: Innervation and "Tonus" of Striated Muscle in Man, Arch. Neurol. & Psychiat. 46:947, 1941.

motor neuron diseases is the key to differential diagnosis of neuromuscular disorders, the need for proper technic and suitable equipment becomes self evident.

The use of multiple channel electromyographs[2] may be desirable for certain clinical investigations and basic neuromuscular research, but it is not needed for routine clinical use. The electroencephalograph may be used successfully in evaluating spasticity, rigidity, sensitivity to stretch reflexes and electrical behavior of antagonistic and synergistic muscles during voluntary and coordinated reflex activity seen in upper motor neuron disabilities. However, in a condition in which there is a question of a mixed upper and lower motor neuron lesion, the reliability of the information thus obtained is highly questionable. With few exceptions these conditions may be examined equally well, and perhaps much better, with the single channel unit similar to the type originally designed by Jasper and Johnson.[1a]

The physiologic principle employed in electromyography rests on one phenomenon, namely, an electrical disturbance is brought about by a process of depolarization when a muscle fiber contracts.[1b] This electrical disturbance has been called an "action potential," "action current" or simply a "voltage" and is associated with some particular type of neuromuscular activity.

The electromyograph has three fundamental uses: (1) to ascertain whether electrical potentials exist in a given muscle; (2) to determine whether the electrical potentials present are normal or abnormal, and (3) to ascertain the type and probable cause of abnormality of the neuromuscular system. In order to determine whether the electrical potentials present are normal or abnormal, it is necessary to examine the voltages from single motor units, i. e., the motor nerve with its quota of one hundred or more skeletal muscle fibers. The needle electrode enables one to do this, since it limits the electrical pick-up to a few muscle fibers. Limitation of the electrical field to a few fibers cannot be accomplished with surface electrodes.

Electromyographic Criteria

The attributes of voltages of bioelectric origin of skeletal muscle, when amplified and examined by a cathode ray oscillograph and a loud speaker system, are used to classify the electrical potentials. These attributes, when viewed on the oscilloscope, are recognized as waves which have certain characteristics, and, when listened to by the loud speaker, have distinctive audio sounds. These characteristics may be summarized as follows: (1) wave form — monophasic, diphasic, triphasic or polyphasic; (2) magnitude of the wave — microvoltage or millivoltage; (3) duration of the wave — milliseconds; (4) frequency of the wave — cycles per second; (5) definitive audiosound — pitch and intensity, producing a characteristic sound.

Quite recently another type of quantitative measurement has been included in electromyography. By using an integrating meter, it is possible to evaluate the relative power of a muscle in terms of electrical units. Bauwens[1b] accomplished this by substituting noninductive resistance for the loud speaker. This rectifies the action currents and measures the electrical energy in terms of microamperes. The electromyograph we employ utilizes an integrating meter device which measures the total electrical energy (summation of action potentials) developed in a given area during muscular contraction and expresses the relative muscle power in terms of effective microvolts. During maximal voluntary effort, the power readings of abnormal and normal

2. (a) Brazier, Mary F. A.; Watkins, A. L., and Michelsen, J. J.: Electromyography in Differential Diagnosis of Ruptured Cervical Disk, Arch. Neurol. & Psychiat. 58:681, 1947. (b) Hoeffer, P. F. A., and Guttman, S. A.: Electromyography as a Method for Determination of the Level of Lesions in the Spinal Cord, ibid. 51:415, 1944. Hoeffer, 1c.

muscles may range from 0 to 1,000 effective microvolts. Power measurements provide some idea of the relative strength of a given muscle at the time of examination. Similar examinations repeated over a period of several weeks or months are valuable in judging whether an injured motor nerve is in the process of degeneration or regeneration.

Principles of Diagnosis Employed in Electromyography

Four diagnostic criteria are used in differential diagnosis: (1) the presence or absence of electrical potentials when the muscle is at rest; (2) the presence or absence of electrical potentials during voluntary effort; (3) if electrical potentials are present, their normal or abnormal characteristics, and (4) the interpretation of the diagnostic significance of electrical potentials having abnormal characteristics.

These principles are employed in the electromyographic diagnosis of all neuromuscular disorders. The first thing to do, of course, is to determine whether a neuromuscular response is present; second, if present, to determine whether it is normal or abnormal, and, third, to evaluate the characteristics of its electrical behavior during rest and during voluntary effort. The last determination enables one to ascertain whether the neuromuscular response is normal or abnormal and makes it possible to identify the probable cause of the abnormality.

Identification of the abnormality present is based on the following knowledge: (1) familiarity with the characteristic electromyographic features of normal and abnormal neuromuscular phenomena; (2) familiarity with the electromyographic characteristics of lower motor neuron disease; (3) sufficient knowledge of clinical neurology to enable the physician to know what to look for and where to find it, i. e., which groups of muscles to sample; (4) familiarity with the electromyographic features associated with the various neuromuscular disorders.

With use of a single channel electromyograph and the needle electrode technic, it is possible to determine accurately the bioelectric characteristics of normal (fig. 1) and abnormal (fig. 3) neuromuscular activity. When a normal muscle is at rest, there is a complete electrical silence,[3] producing an isoelectric base line, and no sound is emitted by the loud speaker. During voluntary effort, simple motor unit voltages develop.[4] The wave form is usually a diphasic spike, but it may be either monophasic or triphasic. The waves have a magnitude ranging from 100 to 2,000 microvolts, a duration of 2 to 10 milliseconds, and a repetition frequency of 5 to 30 per second. A characteristic low-pitched thumping noise is heard in the loud speaker.

The electrical behavior of normal, completely denervated and partially denervated skeletal muscle is shown during rest (absence of voluntary or reflex contraction) and during voluntary effort. At rest, the normal muscle is isoelectric and shows electrical silence. The completely denervated muscle shows fibrillation voltages, and the partially denervated muscle either is isoelectric or shows only fibrillation voltages. In degenerative diseases, such as progressive muscular atrophy, fasciculation voltages may be observed. During voluntary effort, the normal muscle shows simple motor unit voltages, the completely denervated muscle shows only fibrillation voltages and no motor unit response and the partially denervated muscle shows simple and/or

3. (a) Weddell, G.; Feinstein, B., and Pattle, R. E.: The Electrical Activity of Voluntary Muscle in Man Under Normal and Pathological Conditions, Brain 67:178, 1944. (b) Footnote 1. (c) Footnote 2a.

4. (a) Golseth, J. G., and Huddleston, O. L.: Electromyographic Diagnosis in Lower Motor Neuron Disease, Arch. Phys. Med. 30:192, 1949. (b) Huddleston, O. L., and Golseth, J. G.: Electromyographic Studies of Paralyzed and Paretic Muscles in Anterior Poliomyelitis, Arch. Phys. Med. 29:92, 1948. (c) Footnote 1a. Footnote 3a.

complex motor unit voltages.

The characteristics of abnormal voltages associated with lower motor neuron disease result from partial or complete denervation. Examples are shown in figures 2 and 3.

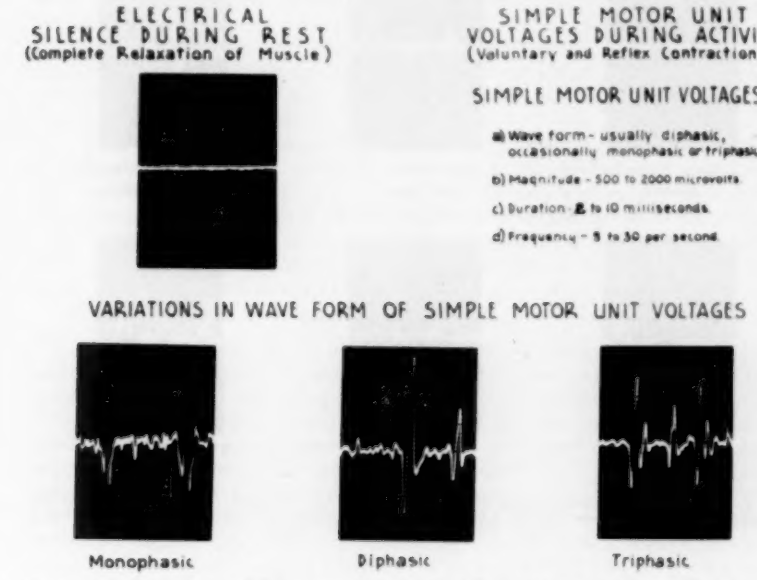
ELECTRICAL
SILENCE DURING REST
(Complete Relaxation of Muscle)
SIMPLE MOTOR UNIT
VOLTAGES DURING ACTIVITY
(Voluntary and Reflex Contraction)
SIMPLE MOTOR UNIT VOLTAGES
a) Wave form - usually diphasic, occasionally monophasic or triphasic.
b) Magnitude - 500 to 2000 microvolts.
c) Duration - 2 to 10 milliseconds.
d) Frequency - 5 to 30 per second.
VARIATIONS IN WAVE FORM OF SIMPLE MOTOR UNIT VOLTAGES
Monophasic
Diphasic
Triphasic

Fig. 1. — Typical electromyograms of normal skeletal muscle obtained with use of "monopolar" needle electrode and oscillograph technic.

Fibrillation voltages[5] (fig. 3) are recognized as monophasic or diphasic waves which range from 10 to 100 microvolts in magnitude, having a duration of 1 to 2 milliseconds and a repetition frequency which varies from 2 to 30 per second. Because of their extremely short duration, they produce a characteristic high-pitched clicking sound in the loud speaker.

Fasciculation voltages[6] may or may not be present, (fig. 2). They are observed usually in partially denervated muscles or in conditions in which there is evidence of irritation of the lower motor neuron unit along the course of its continuity.[7] The characteristics of the fasciculation voltages are the following: The wave form is polyphasic (four or more phases) with voltage magnitudes that range from 20 to 1,000 microvolts, a duration of 5 to 15 milliseconds and an irregular, inconstant repetition frequency. The audio-sound is a characteristic harsh, low-pitched noise. Figure 3 shows examples of the electromyographic characteristics of abnormal electrical reactions in resting and in voluntary contracting muscles shown in diseases and disorders of the lower motor neuron system which manifest varying degrees of denervation.

Complex motor unit voltages[8] (fig. 3) are usually associated with denervation and represent abnormal electrical behavior of either degenerative

5. Footnote 4*a* and *b*. Footnote 3*a*.
6. (*a*) Shea, P. A.; Woods, W. W., and Werden, D. H.: Electromyography in the Nerve Root Compression Syndrome, to be published. (*b*) Footnote 2*a*, *b*. (*c*) Footnote 5.
7. (*a*) Denny-Brown, D., and Pennybacker, J.: Fibrillation and Fasciculation in Voluntary Muscle, Brain **61**:311, 1938. (*b*) Denny-Brown, D.: Interpretation of the Electromyogram, Arch. Neurol. & Psychiat. **61**:99, 1949. (*c*) Footnote 6*a*.
8. Footnote 5. Footnote 6*a*.

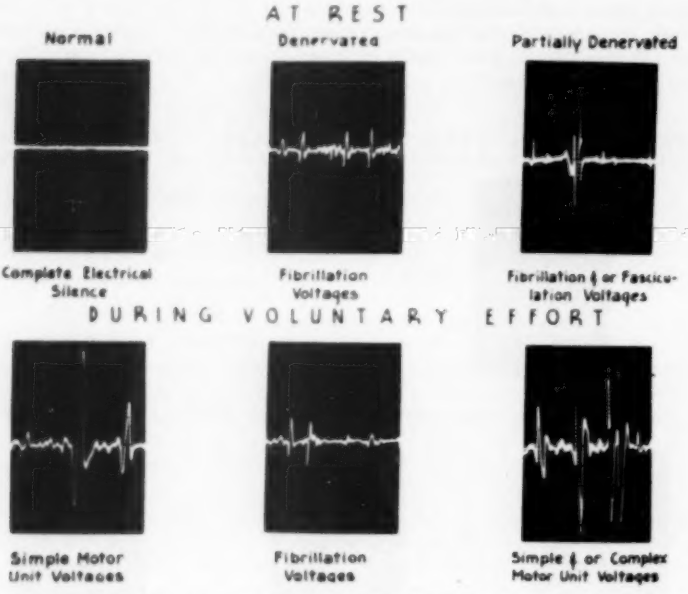

Fig. 2. — Characteristic electromyograms of normal, completely denervated and partially denervated muscle. Complete denervation was recorded from a patient with anterior poliomyelitis and partial denervation from a patient with progressive muscular atrophy.

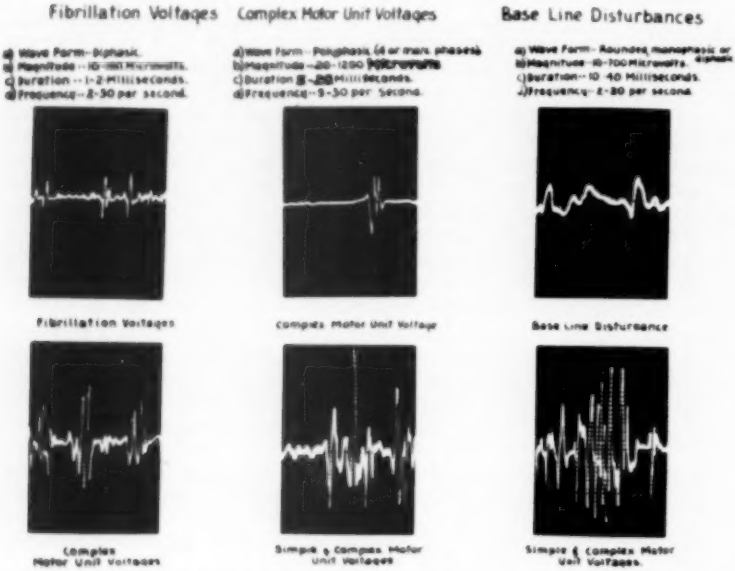
Fibrillation Voltages
a) Wave Form- Diphasic.
b) Magnitude -10-100 Microvolts.
c) Duration --1-2 Milliseconds.
d) Frequency--2-30 per second.
Complex Motor Unit Voltages
a) Wave Form - Polyphasic (4 or more phases).
b) Magnitude --200-1200 Microvolts.
c) Duration 8--20 Milliseconds.
d) Frequency--5-30 per second.
Base Line Disturbances
a) Wave Form- Rounded monophasic or diphasic w
b) Magnitude- 10-700 Microvolts.
c) Duration--10-40 Milliseconds.
d) Frequency- 2-20 per second.
Fibrillation Voltages
Complex Motor Unit Voltage
Base Line Disturbance
Complex Motor Unit Voltages
Simple & Complex Motor Unit Voltages
Simple & Complex Motor Unit Voltages.

Fig. 3. — Electromyograms showing typical abnormal voltage waves which may be observed during voluntary effort in various neuromuscular disorders involving the lower motor neuron system.

or regenerative processes occurring in lower motor neurons. These are polyphasic waves, possessing five or more phases, having magnitudes which range from 20 to 1,200 microvolts, durations of 5 to 20 milliseconds and repetition frequencies of 5 to 30 per second. Owing to their polyphasic wave form and to their long duration, they possess a characteristic harsh, low pitched noise.

Base line disturbances[9] (fig. 3) may be observed early in recovery from neural degeneration. These are usually large, rounded monophasic waves with magnitudes ranging from 5 to 500 microvolts and repetition frequencies of from 2 to 30 per second.

A fairly accurate estimate of the degree of denervation may be ascertained by determining the presence or absence of fibrillation and fasciculation voltages during rest and by determining the presence and extent of base line disturbances, complex motor unit voltages, simple motor unit voltages and power readings in terms of microvolts.[4a] The electromyographic characteristics of the electrical behavior of normal and abnormal neuromuscular activity are summarized in the table.

Differential Diagnosis

Electromyography is a clinical laboratory procedure used to assist in establishing a diagnosis in various types of neuromuscular disorders. It is employed chiefly to determine the type and the probable cause of paralysis of the skeletal muscles. Skeletal muscle may fail to contract in response to a willed act for various reasons: (1) loss of voluntary contraction brought about by abnormalities of the muscle fibers themselves, i. e., muscular dystrophies; (2) disturbed function of the neuromuscular junction, i. e., myasthenia gravis[3a]; (3) degenerative changes of the lower motor neurons,[9] i. e., peripheral nerve injuries; polyneuritis, anterior poliomyelitis, progressive muscular atrophy, amyotrophic lateral sclerosis; (4) functional changes of segmental and long circuiting reflexes,[10] i. e., paraplegia, tabes dorsalis; (5) physiologic block of acute injuries and inflammatory conditions of muscles and joints,[1c] i. e., nondenervated muscles of anterior poliomyelitis ("alienation")[11]; (6) upper motor neuron lesions,[12] i. e., cerebral palsy, hemiplegia, multiple sclerosis, parkinsonism, amyotrophic lateral sclerosis; (7) abnormal cortical functions,[13] i. e., hysteria and malingering.

Examination of the electrical reactions of the muscle to any of these conditions may be of value in determining the type and cause of the paralysis. Some of the outstanding electromyographic features which are used in diagnosing neuromuscular disorders will be mentioned.

Paralysis caused by a disorder of the muscular system proper may show no evidence of denervation,[2a] that is, no fibrillation or fasciculation voltages are present. The muscular responses elicited from weakened muscles by voluntary effort or by electrical stimulation show electrical potentials which resemble those of normal muscle. However, some minor quantitative changes in the voltages may be observed, and the simple motor unit voltages and the power reading in terms of microvolts may be of a low order during maximal muscular contraction.[12]

Disturbances of the function of the myoneural junctions, occurring, for example, in myasthenia gravis,[3a] show a rapid reduction of voltages during sustained contraction for thirty seconds or more. Electrical silence may develop after sixty seconds of sustained maximal contraction. The action po-

9. Footnote 1a, c. Footnote 2a. Footnote b. Footnote 7a, b.
10. Footnote 1c. Footnote 2a.
11. Footnote 1c. Footnote 4b.
12. (*a*) Weddell, G., Feinstein, B., and Pattle, R. E.: The Clinical Application of Electromyography, Lancet 1:238, 1943. (*b*) Footnote 1c. (*c*) Footnote 2a. (*d*) Footnote 3a. (*e*) Footnote 7a, b.
13. Unpublished observations.

tentials become reduced both in size and frequency during the process of fatigue.

Lower motor neuron diseases such as anterior poliomyelitis[14] and progressive muscular atrophy show the characteristic findings of denervation,[15] namely, fibrillation voltages with or without fasciculation voltages during rest and either no motor unit voltages, base line disturbances, complex motor unit disturbances or a mixture of these with simple motor unit voltages during voluntary effort. Fibrillation voltages are characteristically found in the denervation associated with poliomyelitis after the twenty-first day following the onset of the disease.[3] In our experience, fasciculation voltages do not occur in anterior poliomyelitis. Fasciculation voltages plus fibrillation voltages are characteristically found in progressive muscular atrophy in various muscles during different stages of the disease.[16] Peripheral nerve injuries involving the motor supply of skeletal muscles show the typical findings characteristic of lower motor neuron lesions.[17] Essentially the same electromyographic findings occur in amyotrophic lateral sclerosis as in progressive muscular atrophy.

Patients with paraplegia or quadriplegia show no resting action potentials and no fibrillation or fasciculation voltages except in those muscles supplied by the segment of the cord which is injured.[3a] No motor unit responses of any kind are elicited on voluntary effort.

The synaptic block type of paralysis associated with fractures, shock, joint injuries, painful muscles resulting from trauma or inflammation, or the "alienated" muscles of anterior poliomyelitis show no electrical signs of denervation.[18]

Diseases of the upper motor neuron system,[19] unless combined with lower motor neuron lesions, as in amyotrophic lateral sclerosis, show no electromyographic findings characteristic of lower motor neuron disease — that is, no fibrillation nor fasciculation voltages and no complex motor unit voltages. Patients with cerebellar lesions show an essentially normal electromyogram,[3a] though muscles may show an increased susceptibility to fatigue. Patients with Parkinsonism[20] show a constant stream of action potentials which are always present when the muscles are at rest and even during sleep. Fibrillation voltages, fasciculation voltages and complex motor unit voltages are absent. The spastic muscles of cerebral palsy[20] and multiple sclerosis characteristically show neither evidence of denervation nor the constant stream of motor unit voltages which are associated with the rigidity of parkinsonism. In both conditions, however, the stretch reflexes are hyperactive and the position of the extremities or of the body may be sufficient to excite myotatic reflexes and cause simple motor units to appear during rest. With proper positioning and complete voluntary relaxation, the spontaneous electrical responses disappear in spasticity, but not in rigidity.[3c] In spastic hemiplegias[3a] there are no signs of denervation and no evidence of lower motor neuron involvement. During rest there is usually a slow rhythmic outburst of action potentials which show the characteristics of simple motor unit voltages. These are associated with hyperactive stretch reflexes. During sleep the action potentials are diminished, but they do not entirely disappear.

In paralysis resulting from abnormal cortical functions such as hysteria[15]

14. Hansson, K. G., Troedsson, V. S., and Schwarzkopf, E. Electromyographic Studies in Poliomyelitis. Arch. Phys. Med. **23**:251, 1942.
15. Footnote 4b. Footnote 12.
16. Footnote 4a. Footnote 15.
17. Goleth, J. G., and Fitzell, J. A. Electromyographic Studies on Cats After Section and Suture of the Sciatic Nerve. Am. J. Physiol. **150**:558, 1947. Footnote 1a. Footnote 3a. Footnote 4a.
18. Footnote 4b. Footnote 12.
19. Footnote 4b, c. Footnote 5a. Footnote 12a.
20. Footnote 3c. Footnote 5a. Footnote 13.

or malingering,[19] in which the failure of contraction is on an economic or psychologic basis, the characteristics of the electrical behavior of the muscles are normal. It may be necessary to employ reflex contractions or electrical stimulation to elicit muscular contraction. However, when the muscular contractions are thus produced, only simple motor unit voltages are observed and no fibrillation or fasciculation voltages are present.

Spinal cord and anterior nerve root lesions resulting from compression associated with herniated intervertebral disks, tumors or intradural or extradural hemorrhage may be recognized electromyographically. Hoeffer and Guttman,[2b] in 1944, and Brazier, Watkins and Michelsen,[3a] in 1947, reported the presence of fasciculation voltages and motor unit discharges in resting muscles supplied by the segment of the cord at the site of the lesion. Some question concerning the reliability of their methods of diagnosis has been brought out by the report of Shea, Woods and Werden,[6a] who observed the presence of fasciculation voltages in only 50 per cent of 35 patients with proved compression lesions of the anterior nerve roots. These investigators used the needle electrode technic and a single channel electromyograph. A positive diagnosis of a root lesion was made in 100 per cent of the cases, and an accurate localization of the site of the lesion was made in 34 of the 35 cases. In 1 patient, the lesion was erroneously localized at the eighth cervical root, and operation showed a herniated nucleus pulposis compressing the 7th cervical root. The error in localization was later found to have been caused by a faulty placement of the needle electrode. According to Shea and associates, the diagnosis and localization of the level of the lesion is made with an unusually high degree of accuracy when based upon the following findings, listed in the order of their importance: (1) segmental denervation fibrillation arising from one single segment or root; (2) complex motor unit voltages; (3) fasciculation voltages.

With use of some of the criteria mentioned which are characteristic of neuromuscular disorders, it is possible to make a differential diagnosis among the following conditions: (1) primary muscular dystrophies and primary muscular atrophies; (2) lower motor neuron lesions and upper motor neuron lesions[21]; (3) disuse atrophy and denervation atrophy[3a]; (4) physiologic block and lower motor neuron lesions[22]; (5) organic paralysis and a functional paralysis[4a]; (6) backache caused from acute and chronic postural strain and that caused from nerve root compression lesions.[23]

Electromyography now affords a means of obtaining positive quantitative data in all neuromuscular disorders associated with lower motor neuron lesions. Qualitative and quantitative data other than characteristic findings of lower motor neuron disease may be secured in muscle disorders as well as in cortical and upper motor neuron lesions. The presence or absence of the signs characteristic of denervation provide very important information which will assist in the differential diagnosis of numerous neuromuscular disorders. A significant point of practical importance is that electromyographic findings are now accepted by the courts as reliable diagnostic evidence.[24] Information showing the absence or presence, extent and cause of organic neuromuscular involvement becomes of extreme importance in the settlement of medical legal cases.[24a]

Summary

The present and future status of electromyography is discussed.

A brief discussion is presented regarding the proper selection of equipment and technic. It is pointed out that for routine clinical work only a

21. Footnote 1a. Footnote 3a. Footnote 4a. Footnote 12a.
22. Footnote 2a. Footnote 18.
23. Personal communication to the authors. Footnote 12.
24. (a) Golseth, J. G.: The Medical-Legal Aspects of Electromyography, to be published.

single channel electromyograph is required and that the needle electrode technic is preferable when used to assist in the diagnosis of neuromuscular disorders.

The important physiologic principle used in electromyography is the detection and proper examination of the electrical potentials of skeletal muscles associated with contractile process of the muscle fibers.

The electromyographic criteria used in classifying voltages associated with muscular contraction are those of (*a*) wave form, either simple or polyphasic; (*b*) magnitude of voltages, either of a single wave or of voltages of a series of waves — "power readings" — over a given period of time; (*c*) duration in milliseconds; (*d*) frequency of waves in terms of cycles per second; (*e*) audiosound of the various waves.

Summary of Significant Electromyographic Characteristics of Normal and Abnormal Waves[a]

Name of Wave	Wave Form	Magnitude of Wave Microvolts	Duration of Wave Milliseconds	Frequency of Wave	Audio Sound	Diagnostic Significance
Simple motor unit voltage occurring during voluntary effort	Monophasic *Diphasic* Triphasic	100 to 3000	2 to 10	5 to 30	Low-pitched thumping sound	Normal neuromuscular contraction
Fibrillation voltages occur during rest	Monophasic *Diphasic*	10 to 100	1 to 2	2 to 30	High-pitched clicking sound	Abnormal wave signifying denervation
Fasciculation voltages occur during rest	Polyphasic (4 or more phases)	20 to 1000	5 to 15	Irregular inconstant repetition frequency	Harsh, low-pitched noise	Abnormal wave associated with degeneration or irritation
Base line disturbance (occurs during voluntary effort)	Monophasic large rounded waves	5 to 500	5 to 30	2 to 30	Distant, muffled soft, indistinct rumbling sounds	Abnormal wave associated with early regeneration or late degeneration
Complex motor unit voltages (occur during voluntary effort)	Polyphasic (5 or more phases)	20 to 1200	5 to 20	5 to 30	Harsh, low pitched noise	Abnormal wave associated either with degeneration or regeneration

[a] Using needle electrode, high gain amplifier, cathode ray oscillograph and loud speaker.

The electromyographic characteristics of normal and abnormal neuromuscular responses were discussed.

The significant electromyographic phenomena shown in the examination of patients with suspected neuromuscular disorders are those of normal and abnormal reactions. Normal neuromuscular responses are characterized by electrical silence during rest and simple motor unit voltages during voluntary effort. Abnormal conditions may show the presence or absence of denervation. The diagnostic features associated with lower motor neuron diseases show the presence of spontaneous electrical potentials while the muscles are at rest, i. e., fibrillation voltages with or without fasciculation voltages. During voluntary effort, motor unit voltages are absent in complete denervation, and the presence of base line disturbances, complex motor unit voltages with or without a mixture of these with simple motor unit voltages, indicates partial denervation.

The dominant electromyographic features of various types of paralyses resulting from primary diseases or disorders of the skeletal muscles, the neuromuscular junctions, lower motor neuron, functional disorders of the seg-

mental and long circuiting reflexes, upper motor neuron and cortical abnormalities are presented.

Combining electromyographic data with other clinical data facilitates the differential diagnosis of such conditions as primary muscular dystrophies and atrophies; upper and lower neuron diseases; rigidity and spasticity of skeletal muscles; physiologic block and organic nerve lesions; hysterical paralysis or malingering and organic paralysis; backache of acute or chronic postural strain and that of compression lesions.

In addition to its use in differential diagnosis, electromyography may be employed to identify the segment of the spinal cord or spinal nerve root or roots involved in a compression lesion.

Electromyography may be used also in securing objective evidence for court testimony in medical legal cases.

CARE OF UPPER EXTREMITY PARALYSIS IN POLIOMYELITIS *

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NEW YORK

In a series of cases of infantile paralysis from 1931, covering 54 patients, the end result was that about 70 per cent of the patients recovered completely, 18 per cent had slight residual paralysis and 12 per cent had severe paralysis. The distribution of the paralysis was as follows: one upper extremity, 19 per cent; both upper extremities, 4 per cent; one lower extremity, 50 per cent; both lower extremities, 12 per cent, and both lower and upper extremities, 15 per cent. Thus there was involvement of the upper extremities of 38 per cent.[1] While braces are used to support the weight in paralysis of the lower extremities, there is no adequate substitute for paralysis of the upper extremities. Therefore, the patient who has lower extremity paralysis is somewhat limited in locomotion, while the patient with upper extremity paralysis is greatly handicapped when it comes to making use of his normal lower extremities. The patient with upper extremity paralysis can move about but cannot take advantage of his activities. Complete paralysis of both upper extremities is probably the most devasting after-effect of poliomyelitis. It therefore becomes very important that all possible steps be taken to prevent such paralysis and also all possible care be devoted to minimize the residual after-effects of poliomyelitis in the upper extremities.

In recent years, therapeutics has been overemphasized and a compromise has been made on long-established laws of prevention. I therefore want to repeat the old established formula for treating peripheral nerve lesions:

In analyzing muscle action, one must differentiate between concentric

1. Weakened muscles should be held in the neutral position. The muscles involved must always be supported in such a way that overstretching is impossible.
2. Gravity must be eliminated.
3. Adequate blood supply must be maintained.

* Read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine, Sept. 9, 1949.

1. Hansson, K. G.: After Treatment of Poliomyelitis, J. A. M. A. 111:32 (July 1) 1939.

and eccentric muscles. These muscles act together as antagonists, and their action depends on muscle tone for smooth performance. The concentric and eccentric muscles are also synergistic in their action. Overstretching of muscles, in addition to producing atrophy, may also produce fibrosis.

The constant presence of gravity must be remembered when weak muscles are present. This is important not only in standing but also in the sitting and lying positions. One should remember also that overstretching of muscles will elongate the blood vessels and thereby diminish the blood supply to the muscle. All these factors mentioned are especially pronounced when the patient's metabolism is at low ebb.

The greatest problems that I have encountered have been in patients who have been confined in respirators. In them one sees muscle atrophy, muscle contractions, freezing of the capsule and, consequently, deformities.

Serratus Magnus Paralysis

In the general muscle examination of the patient with poliomyelitis it is very easy to overlook the depressors of the scapula. The main depressor muscle is the serratus magnus. This muscle is inervated by the long thoracic nerve, or external respirator nerve of Bell. This muscle originates from the anterior rib cage and is inserted in both superior and inferior angles of the scapula. The function of the serratus magnus is three-fold:

1. As a stabilizing force, it fixes the scapula when the pectoralis minor muscle is actively used in deep breathing and when the triceps delivers a blow.

2. As a balancing force, it counteracts the trapezius, rhomboids and levator scapulae muscles. It also counteracts the rotating force produced by the weight of the arm.

3. As an active force, it thrusts the scapula forward, thereby increasing the reach of the hand and it raises the chest when the scapula is stabilized.

Because of this function, it follows that a paralyzed serratus magnus muscle would produce two deformities: a protrusion of the scapula from the thoracic wall and a rotation of the scapula due to the weight of the arm.

Treatment. — Support: In order to prevent overstretching, one must use a brace that holds the scapula close to the thorax, and the scapula must also be derotated. Elevation of the arm must also be prevented. Such immobilization can be produced by a leather brace covering the upper part of the chest and shoulder with a sleeve that goes down on the arm and prevents elevation. This brace is held by means of a strap across the chest. The brace is made from the mold of the patient's shoulder. It should be worn day and night until the protrusion and rotation are corrected. This time varies from three months to a year.

Stimulation: While the serratus magnus muscle is immobolized, an attempt is made to stimulate this muscle by heat and electrical contractions. The muscle can be found between the pectoralis major and latissimus muscle above the external oblique muscle. Interrupted galvanic stimulation is used first; faradic stimulation is used after the muscle responds to the galvanic stimulation.

Exercises: Exercises are of two types: The first consists of voluntary attempts to contract the serratus magnus. This is done by a forward thrust of the shoulder girdle. The patient sits at the side of the table with the arm resting on the surface of the table and then slides the arm forward. Any form of push-up can be performed against the wall or against a table with the body at a 60 degree angle to the table. It can also be done in the prone position on the floor or on hands and knees by pushing the body weight away

from the floor. The other type of exercise is concerned with the supporting muscle of the serratus magnus, the trapezius — especially the lower part — and the rhomboids. These exercises are repeated at each of the patient's visits and also performed by him three times a day at home.[2]

Shoulder Joint

This joint has all the unfavorable factors for producing residual contraction. These factors are gravity, leverage, and phylogenesis. One of the most difficult problems in after-treatment of poliomyelitis is the frozen shoulder that appears in patients who have been in a respirator for any length of time. In them one sees contracture of the capsule and shortening of the adductors and stretching of the abductors. The general consideration of the shoulder may be best discussed by referring to an actual case:

A little girl, 5 years old, contracted poliomyeiitis in September, 1946. On November 26 she presented a picture of complete paralysis of the right deltoid muscle. Supraspinatus, biceps and triceps showed fair muscle power. There was atrophy of the supraspinatus and infraspinatus fossa, and the circumference of the right arm was ¼ inch less than the left one. She had been treated with hot packs and muscle reeducation exercises. All these treatments were continued daily until Jan. 15, 1947. At this time, there was no change in the muscle power about the shoulder. I advised an airplane splint, which was refused. The child's father, who was a practicing physician, shopped around among various physicians and got different advice, until he finally returned to me and the patient's right shoulder was placed in an airplane splint and treatment changed to electrical stimulation of the weakened muscle, followed by muscle reeducation. This treatment was continued during the year of 1947, and on Jan. 28, 1948, the patient had recovered use of the supraspinatus and infraspinatus muscles, the anterior and middle deltoid, the biceps and the triceps. It was interesting to notice that the modern airplane splint holds the arm in slight flexion and thereby overstretches the posterior part of the deltoid. This may explain the persistent weakness of the posterior deltoid. The main change in treatment during 1948 was the addition of weight lifting. The patient started with dumbbells of ½ pound weight, and at the end of the year used 5 pound weights. She also did much swimming in the summer of 1948. Use of the airplane splint was discontinued on January 8. The only treatment followed since then has been swimming and weight lifting. When last examined, on April 21, 1949, all the muscles about the right shoulder had recovered except the posterior deltoid, which was marked as fair.

The experience gained from such a patient and many other similar cases shows the definite value of (1) supporting the weakened muscle; (2) electrical stimulation to a definite group of muscles, and (3) weight lifting, which is probably the best exercise for producing muscle power.

Elbow

The elbow is characterized by antagonistic pull of the biceps for flexion and the triceps for extension. The general principal holds true here that weakness of flexion should be treated with the elbow held at 90 degrees, while weakness of the triceps can be treated with the arm hanging at the side. The absence of flexion in the elbow is the most serious one, because even a normal hand would be useless if it could not be approximated to the face. A substitution movement is usually present when the biceps is absent, and this is due to the use of brachialis and the extensor muscle, which takes origin from the external epicondyle. The brachialis muscle has a double innervation from both the musculocutaneous and the radial nerve. If the forearm is pronated, the patient is able to flex the elbow by means of substitution of the brachialis and the brachioradialis. This fact is an underlying principle for operations on patients with paralyzed biceps. This operation consists in replacing the origin of the extensor muscles and the epichondyle higher up on the humerous.

2. Hansson, K. G.: Serratus Magnus Paralysis, Arch. Phys. Med. 29:156 (March) 1948.

In a completely paralyzed arm with an active hand it is sometimes possible to make use of the same principle on which an artificial arm is built: A wire is attached to the forearm, running up to the axilla and across the upper part of the body and around the opposite shoulder in such a way that when the opposite shoulder is brought forward the forearm on the paralyzed side will be flexed.

The problem in the after-treatment of poliomyelitis of the hand resolves itself into four parts.

1. *Radial Nerve Paralysis.* — When the radial nerve is paralyzed, it is recognized by a dropped wrist and inability to extend the fingers. The three extensors of the wrist are unable to raise the wrist against gravity, and the extensors of the thumb are unable to abduct and extend the thumb. Paralysis of the extensor digitorum communis shows itself in inability to extend the fingers. This lack of complete extension of the fingers should not be confused with extension of the fingers produced by the lumbricales.

The type of support required for radial nerve paralysis is, therefore, a splint that holds the wrist in slight extension and fingers in extension. This is best supplied by a spade splint whereby each individual finger is held in position by means of a leather strap. The rest of the treatment consists of electrical stimulation to maintain the tone of the muscles, massage for the circulation of the hand and muscle reeducation exercises.

2. *Medial Nerve Paralysis.* — This is characterized by hyperextension of the wrist and loss of apposition of the thumb, which is usually held in abduction and extension. The apposition of the thumb against the other fingers is the most important function of the hand. Therefore, one should not neglect the placing of the thumb in a proper position so that the opponens muscle is not over stretched. There are various splints for this purpose, but the principle of the immobilization should be based on slight rotation forward and inward of the first metacarpal and flexion of the thumb.

3. *Ulnar Paralysis.* — This is characterized by atrophy of the intrinsic muscle and hypothenar eminence. When the flexor carpi ulnaris is paralyzed, it is often difficult to test for this muscle. However, atrophy of the hypothenar eminence is easily recognized, and the fourth and fifth fingers are held in flexion. The most important aim in the mobilization is to prevent flexion contraction of these two fingers and, also, to maintain their adduction.

4. *Complete Paralysis.* — When all three nerves of the hand are paralyzed, the hand is usually found with the wrist in slight flexion, the palm is flat, the thumb is held in abduction in the same plane as that of the palm, the metacarpophalangeal joints are held in slight extension and the interphalangeal joints are in slight flexion.

The immobilization of such a completely paralyzed hand should be that of physiologic position of grasp.[1] This means that the wrist is dorsiflexed about 30 degrees and without medial or ulnar deviation. The thumb is in the position of full abduction and is retained in apposition in such a way that the plane of the four inner metacarpals meet the plane of the first and second intercarpals at nearly a right angle. The metacarpophalangeal joints are flexed 15 to 20 degrees from the straight position and the interphalangeal joints 10 to 15 degrees. The angle formed by the shafts of the first and second metacarpals is approximately 60 degrees. With the hand and wrist in such a position and the forearm midway between supination and pronation, the treatment should consist mainly of electrical stimulations, massage and muscle reeducation.

1. Cochrane, W. A.: Orthopaedic Surgery, Baltimore, William Wood & Company, 1926, p. 415.

Various apparatus and gadgets have been recommended for patients with upper extremity paralysis. Four of these are worthy of mention:

(*a*) An overhead spring sling has been recommended by Bennett.[4] This is an assistive apparatus for patients with weak arms but active hands. It can be attached to the bed, a table or wheel chair.

(*b*) The next apparatus can best be illustrated by recounting the history of one of my patients. This patient had been severely paralyzed in all four extremities and the trunk. Both legs were useless, and the left arm was nearly so. When she came to the time for locomotion in a wheel chair, she could use only one hand on the wheel, and consequently the chair only turned around. A wheel chair with two extra rings on the wheel of one side is now on the market. Patients who have only one active upper extremity can turn one ring to go to the right and one ring to go to the left. When both rings are grasped, the wheel chair goes straight forward.

(*c*) Another useful apparatus is the electric typewriter. This requires only minimal touch, and its use made it possible for the patient to be an assistant to my secretary. She is a very useful addition to the hospital staff, because she has learned shorthand and typewriting and can propel her own wheel chair.

(*d*) The fourth apparatus is a motor-driven wheel chair that can be used by patients totally paralyzed in both lower extremities and one upper. It is controlled by one lever, by which the motor is started either forward or backward and which can also be used for the steering of the wheel chair. The motor runs on batteries, is quite noiseless and is geared to a speed of three miles on hour.

Summary

The residual symptoms of poliomyelitis are (1) spasm, (2) paralysis and (3) deformity. Spasm is most prevalent in the acute stage, may or may not be found in the subacute stage and should be absent in the chronic stage. Anything in therapeutics, be it physical or pharmaceutic, that will relieve spasm may be used. However, one must be sure that all muscles are stretched to their normal length. Paralysis sets in during the acute stage, is most prominent in the subacute stage and is found in the chronic stage in about 30 per cent of patients. The treatment should include proper support of paralyzed muscles in the physiologic rest position to prevent overstretching of muscles. Muscle reeducation exercises are the principal activities for recovering of function of muscles, but electrical stimulation and weight lifting should also be included. If muscle spasm has been released and weak muscles supported, there should be no deformity, theoretically speaking. However, when encountered, one should not hesitate to recommend braces and supports or orthopedic surgery.

Conclusions

Paralysis of upper extremities is more disabling than similar paralysis of lower extremities. It therefore becomes more important to observe all preventive and therapeutic measures.

1. The principal therapy, the after-effects of poliomyelitis anywhere, is to release spasm, support and strengthen weakened muscles and prevent deformity.

2. It is especially necessary to use the proper brace in case of paralysis of serratus magnus and deltoid muscles.

4. Bierman, W.: Physical Medicine in General Practice, New York, Paul B. Hoeber, Inc., p. 184.

3. Electrical stimulations are indicated when one muscle or a small muscle group is paralyzed.

4. Weight-lifting exercises are recommended for increasing strength of muscles.

The discussion of this paper will appear in a later issue of the ARCHIVES.

THE EFFECT OF PARALYSIS OF ONE LOWER-EXTREMITY ON BONE GROWTH *

Preliminary Report

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One of the deformities which may follow poliomyelitis is a discrepancy in the length of the bones of the lower extremities. If the discrepancy becomes too great and there is an accompanying decrease in muscle power, the resulting disability becomes serious. In an attempt to elucidate some of the factors responsible for discrepancies in growth of the lower extremities following poliomyelitis, a series of studies have been started. This report is concerned with the relation between the amount of atrophy of the thigh or leg, the strength of the muscles in the lower extremities and the exact length of the tibia, the femur and the entire lower extremity.

Methods

Patients were studied who had had acute poliomyelitis three to seven years previously, who were treated adequately by hot packs, early mobilization and muscle reeducation, who were in the growing age period (14 years or younger) at the time of onset, and who had involvement of only one lower extremity with a normal uninvolved extremity on the opposite side.

Roentgenograms were taken of the normal and the involved lower extremities, with use of a method of orthoroentgenography similar to that described by Green, Wyatt and Anderson.[1] Roentgenograms were made with the central rays of the tube directed perpendicularly to the length of the bone and centered over each end of the bone. The exact length of the femur, tibia and lower extremity then could be determined by measurements from the x-ray plates. The femur was measured from the greater trochanter to the medial condyle, the tibia from the intercondyloid eminence to the medial malleolus and the total leg length from the greater trochanter to the medial malleolus. The differences in length between the tibia, the femur and the

* Aided by a grant from the National Foundation for Infantile Paralysis, Inc.
† From the Division of Physical Medicine, University of Minnesota.
* Read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine, Cincinnati, Sept. 19, 1949.
1. Green, W. T.; Wyatt, G. M., and Anderson, G. M.: Orthoroentgenography as a Method of Measuring the Bones of the Lower Extremities, J. Bone & Joint Surg. 28:150 (Jan.) 1946.

lower extremity on the involved and the uninvolved sides are expressed here as "percentage shortening," the uninvolved extremity serving as the standard.

All patients were examined for the amount of muscle power present in both lower extremities and the amount of strength was recorded with use of the modified Lovett method recommended by the National Foundation for Infantile Paralysis, Inc., in which 0 indicates no strength, 1 trace, 2 poor, 3 fair, 4 good and 5 normal. The following groups of muscles were examined:

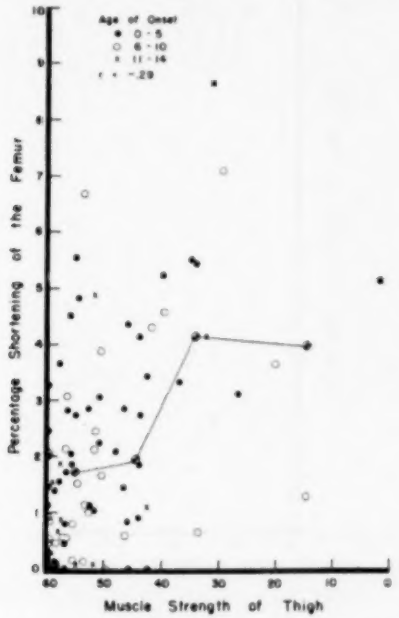

Chart 1. — Relation between muscle strength of the thigh and percentage shortening of the femur in the involved extremity. Each dot represents 1 case. The age at onset is indicated by solid dots for 0 to 5 years, open dots for 6 to 10 years and crosses for 11 to 14 years. The solid line indicates the average relation between muscle strength and percentage shortening for the entire group. *R* is the correlation coefficient. Plus or minus 1 equals complete correlation. *R* = —0.29.

Gluteus maximus; long hip extensors; iliopsoas; sartorius; tensor fasciae latae; gluteus medius; adductors of the thigh; internal rotators of the thigh; external rotators of the thigh; quadriceps; inner hamstrings; outer hamstrings; gastrocnemius-soleus; tibialis anterior; tibialis posterior; peroneals; extensor digitorum longus; extensor proprius hallucis; flexor digitorum longus, and flexor hallucis longus. The total muscle strength of the thigh, leg and entire extremity was then expressed as summation of the individual muscle scores. Thus a thigh with normal strength would be expressed as 60, a leg with normal strength as 40 and a normal extremity as 100.

As a measure of the degree of atrophy present, comparative measurements were recorded of the circumferences of the two lower extremities at selected levels. The circumferences of the thighs were measured at two places — the middle of the upper third, and the middle of the lower third.

The tibial tubercle was used as a reference point to make certain that the two thighs were measured at the same level. The circumference of the calves were measured at the level of the greatest circumference of the uninvolved leg, the medial malleolus being used as the reference point. The amount of atrophy is expressed as "percentage atrophy," and was obtained by dividing the difference in circumference of the two compared levels by the cir-

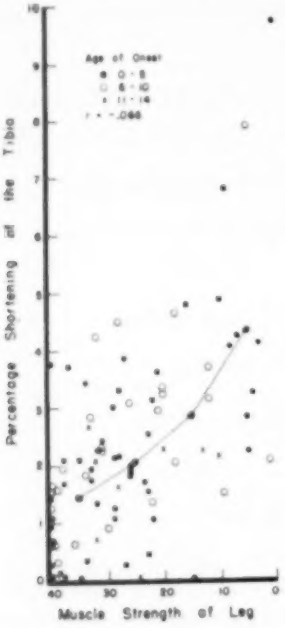

Chart 2. — Relation between muscle strength of the leg and percentage shortening of the tibia in the involved extremity. $R = -0.66$.

cumference of the normal extremity at that level. A value for the amount of atrophy for the entire lower extremity was arrived at by summation of the percentage atrophy values obtained.

Results

Eighty-eight patients have been studied in this series. Chart 1 indicates the relation between muscle strength of the thigh and the shortening of the femur. Muscle strength is recorded on the abscissa; shortening in percentage, on the ordinate. The age of onset is indicated by the solid dots for 0-5 years, the open dots for 6-10 years and the crosses for 11-14 years. The solid line indicates the average relation between muscle strength and percentage shortening for the entire group. The coefficient of correlation between the muscle strength of the thigh and the shortening of the femur is —0.29. Correlation is complete with a coefficient of 1.0 and diminishes toward 0. In the same manner, chart 2 indicates the relation between muscle strength in the leg and shortening of the tibia. The coefficient of correlation between the muscle strength of the leg and the shortening of the tibia is —0.066. Chart 3 illustrates the relation between the total muscle

strength of the lower extremity and the shortening of the lower extremity. The correlation coefficient between muscle strength for the lower extremity and percentage shortening of the lower extremity is —0.68.

Charts 4 and 5 show the relation between atrophy of the upper and lower parts of the thigh and the shortening of the femur. The correlation coefficient for the relation between atrophy of the upper part of the thigh and femoral shortening is +0.082. The correlation coefficient for the atrophy

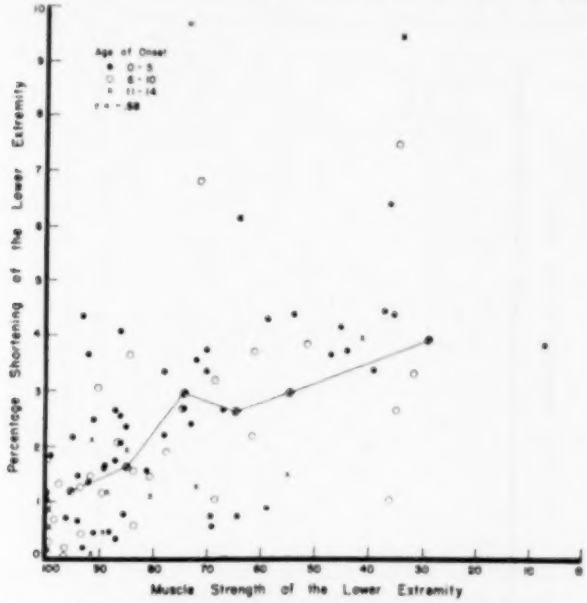

Chart 3. — Relation between muscle strength of the lower extremity and percentage shortening of the lower extremity on the involved side. $R = -0.68$.

of the lower part of the thigh and femoral shortening is +0.592. Chart 6 indicates the relation between atrophy of the calf and shortening of the tibia. The correlation coefficient for atrophy of the calf muscles and shortening of the tibia is +0.764. Chart 7 indicates the relation between the combined atrophies of the lower extremity and the total shortening of the lower extremity. The correlation coefficient is +0.652.

The relation between muscle strength and atrophy was also evaluated. The correlation coefficient for the relation between the muscle strength of the thigh and the atrophy of the upper part of the thigh was —0.343 and for the relation between thigh muscle strength and atrophy of the lower part of the thigh it was —0.483; for the relation between muscle strength of the leg and atrophy of the leg it was —0.84, and for total strength of the lower extremity and total atrophy of the lower extremity it was —0.861.

The effect that the age of the onset of acute poliomyelitis has on the amount of shortening that will occur is indicated in the table. The average percentage shortening for each of the three groups, 0 to 5 years, 6 to 10 years and 11 to 14 years is shown. There appears to be no significant difference between the 0 to 5 year and the 6 to 10 year age groups. A smaller amount of shortening is seen in the 11 to 14 year age group. This may be related to approaching bone maturity.

Comment

From these studies carried out on 88 patients who had had acute poliomyelitis more than three years previously, it appears that there is a correlation both between soft tissue atrophy in the involved extremity and the retardation of bone growth and between total muscle strength of the involved extremity and the retardation of bone growth.

Although the correlation coefficients in none of these cases are high enough for there to be certainty of prediction that atrophy in the soft tissue

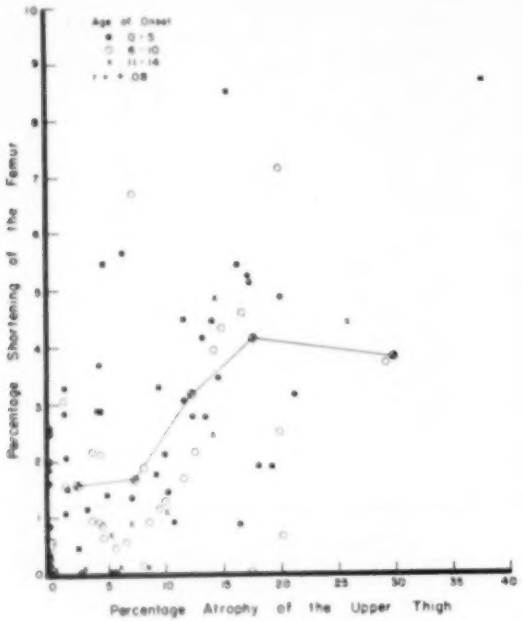

Chart 6. — Relation between atrophy of the upper part of the thigh and percentage shortening of the femur in the extremity involved by poliomyelitis. $R = +0.08$.

will be followed by a decrease in growth of the bone, the charts show a trend relation between soft tissue atrophy and bone shortening. The probability that these correlations are due to chance in random sampling is less than 0.001 except in the case of atrophy of the upper part of the thigh, in which the relation is not significant. This correlation is greatest in the relation between atrophy of the calf and diminution of growth in the tibia in the involved extremity. Atrophy in the lower part of the thigh appears to be significant, whereas atrophy in the upper third of the thigh is not related to shortening of the femur. This may be due to the greater amount of fat padding the upper part of the thigh, which masks the amount of atrophy which has occurred. Similarly, a value for combined atrophy of the thigh and calf obtained by adding the percentage atrophy obtained from each level when compared to the diminution in growth of the total length of the extremity shows a significant relationship. That there are drawbacks in evaluating lower extremity atrophy by measurements at given levels is recog-

nized. It is possible that if volume changes in the extremity were measured, a closer correlation would occur with the amount of bone shortening.

When shortening in the involved extremity is evaluated against the strength of the muscles in the extremity, it is found that there is a significant though much poorer relation between the strength in the thigh and the shortening of the femur than for atrophy. There is no correlation between strength in the leg and shortening of the tibia. When shortening of total lower ex-

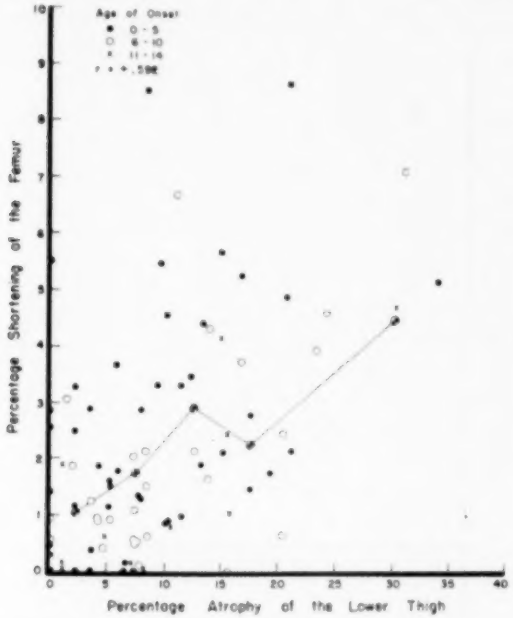

Chart 5. — Relation between atrophy of the lower thigh and percentage shortening of the femur in the involved extremity. $N = +0.592$.

tremity length is compared with lower extremity strength, there is a significant relation (chart 3). The factors that relate growth of the bone to total strength in the extremity, rather than to strength of the muscles surrounding the bone involved, are not understood. It is possible that bone growth will be found to be related to activity of the extremity rather than to absolute strength, and therefore muscles at a relatively distant site from the bone will have an influence on growth.

Comparison of muscular atrophy in the involved extremity against muscular strength showed that in the upper third of the thigh there was less correlation ($p = 0.002$) than in the lower part of the thigh, calf and entire extremity, where the chance of error due to random sampling is less than 0.001. Nevertheless, except in the leg and in evaluating total atrophy against strength, the reliability of prediction that muscle weakness will be associated with atrophy is poor.

The age of onset of acute poliomyelitis apparently has little effect upon the amount of shortening that will occur (table). It was found that patients

Relation Between Age at Onset of Acute Poliomyelitis and Retardation of Bone Growth Indicated as Percentage Shortening in Relation to the Normal Extremity

Age at Onset	Number of Cases	Percentage Shortening of Tibia	Percentage Shortening of Femur	Percentage Shortening of Lower Extremity
0-5	42	2.44	2.52	2.64
6-10	29	2.37	1.96	2.14
11-14	12	1.39	1.40	1.27

who had poliomyelitis in the 0 to 5 year age group did not appear to have a significantly greater percentage of shortening than did the 6 to 10 year age

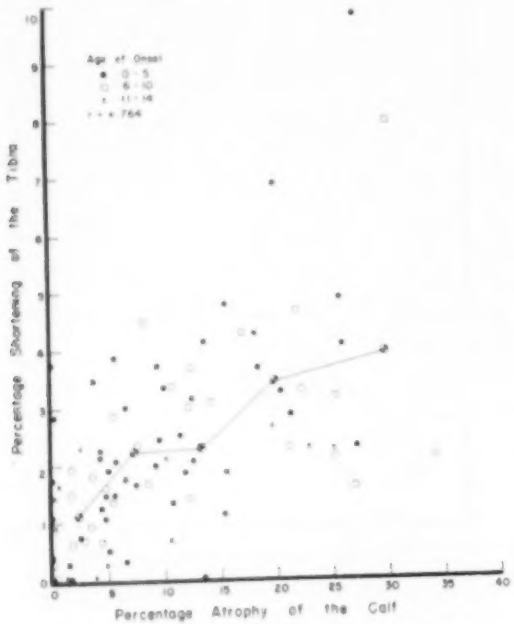

Chart 6. — Relation between atrophy of the calf and percentage shortening of the tibia in the involved extremity. $R = +0.764$.

group. In the 11 to 14 year age group there was an appreciable decrease in the amount of shortening. This is related to approaching bone maturity. The variability of the time of bone maturity in different persons may be as much as four or five years.[2] Stinchfield, Reidy and Barr[3] in their series of cases also found no specific relationship between the amount of discrepancy in bone growth and the age at onset of poliomyelitis.

It appears that functional use of the involved extremity plays a large role in determining whether or not diminution in growth of the bone occurs. There undoubtedly are a number of factors concerned here. Abramson[4] made a study of adult patients with peripheral paralysis due to lesions of the spinal cord and cauda equina with both spastic and flaccid paralysis. He found

2. Green, W. T., and Anderson, G. M.: Experiences with Epiphyseal Arrest in Correcting Discrepancies in Length of the Lower Extremities in Infantile Paralysis, J. Bone & Joint Surg. **29**:659 (July) 1947.
3. Stinchfield, A. J.; Reidy, J. A., and Barr, J. S.: Prediction of Unequal Growth of the Lower Extremities in Anterior Poliomyelitis, J. Bone & Joint Surg. **31-A**:478 (July) 1949.
4. Abramson, A. S.: Bone Disturbances in Injuries to the Spinal Cord and Cauda Equina (Paraplegia), J. Bone & Joint Surg. **30-A**:992 (Oct.) 1948.

that a large percentage of the patients showed bone atrophy of varying severity. He found that intermittent weight bearing was the necessary stimulus for the laying down of new bone matrix. It appears likely that in poliomyelitis, too, the lack of normal weight-bearing function and activity and their stimulating effect on bone metabolism are important factors in the development of discrepancies in leg length. In this regard it should be emphasized that muscle strength as tested here is not necessarily a test of function of

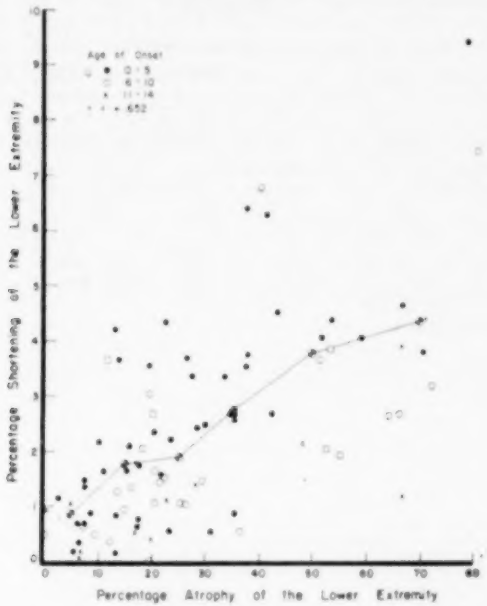

Chart 7. — Relation between atrophy of the lower extremity and percentage shortening of the lower extremity on the involved side. Percentage of shortening is plotted on the ordinate and percentage of atrophy on the abscissa. $R = +0.652$.

the lower extremity. Weight bearing and walking may occur to the same degree in persons with markedly different muscle strength as determined by the manual muscle tests. For this reason it is not surprising that the correlation between muscle strength of the extremity and diminution of rate of bone growth is no better.

Use of the extremity may also alter factors in circulation and nutrition in the extremity. Smith and his co-workers[5] found that in acute poliomyelitis angiospasm existed apparently as a result of involvement of the lateral horn of the spinal cord, where the sympathetic nerves have their origin. Patients with poliomyelitis frequently have been observed to have cold, clammy and cyanotic extremities which may be diagnosed clinically as due to increased sympathetic activity. These patients may show improvement following sympathetic blocks or the use of sympathicolytic drugs. Haas[6] has shown that there is a marked decrease in growth when the epiphysial blood supply is

5. Smith, E.; Rosenblatt, P., and Limauro, A. B.: The Role of the Sympathetic Nervous System in Acute Poliomyelitis, J. Pediat. 34:11 (Jan.) 1949.
6. Haas, S. L.: The Relation of the Blood Supply to the Longitudinal Growth of Bone, Am. J. Orthop. Surg. 15:187, 1917.

interfered with. It would seem reasonable to suppose that in poliomyelitis when there is a decrease in blood flow due to increased sympathetic activity or to decreased function of the leg, there would be an interference with bony and soft tissue metabolism and therefore with growth.

Summary

Eighty-eight cases of chronic poliomyelitis with unilateral involvement of a lower extremity in patients 6 months to 14 years of age at onset were examined three to seven years later. The relation between muscle strength, atrophy and discrepancies in growth of the involved femur, tibia and total lower extremity were analyzed. No correlation was found between muscle strength of the leg and shortening of the tibia. Significant but very poor correlation was found between the muscle strength of the thigh and shortening of the femur. There was a definite correlation between atrophy of the thigh or leg and shortening of the femur or tibia, between total strength of the involved extremity and shortening in that extremity and between total atrophy and shortening of the involved extremity. The age at which acute poliomyelitis occurred appeared to bear no relation to the amount of shortening up to the time of bone maturity. The factors which may be related to soft tissue atrophy and diminution of bone growth have been considered.

A PROGRESSIVE RESISTANCE EXERCISE APPARATUS FOR PHYSICAL REHABILITATION OF PATIENTS WITH AMPUTATIONS, FRACTURES AND PARALYSES OF THE LOWER EXTREMITY *

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The purpose of this paper is to describe an apparatus which permits the adaptation of DeLorme's progressive resistance exercises to conditions for which the conventional setup is not adequate. The apparatus is constructed for the performance of hip and knee exercises by above-knee and below-knee amputees as well as for the early treatment of patients with fractures of the thigh or lower leg and also with paralyses of the ankle or foot.

Since 1945, when DeLorme first published[1] his exercise method of progressive resistance, many physical medicine institutions have accepted his system, either fully or in partly modified forms. A number of publications have shown the advantages of progressive resistance exercises.[2] Eliminating the monotony of exercises invites the cooperation of the patient, specially the average mechanical-minded patient. The intelligent patient enjoys observing objective signs of progress, and no other system has supplied physician and therapist with so good a tool to record muscular function and progress as progressive resistance exercises have done. The clinical results regarding the development of muscle strength and muscle volume have been favorable.[3]

There is no debate on the convenience and versatility of the commercial exercise table. However, certain special indications, which will be discussed in detail, have influenced one of us (M.M.C.) to design an apparatus which can be used with or without the table. Basically the apparatus (fig. 1) resembles a brace with two uprights, knee joint with lock and laced leather cuffs for thigh and lower leg. The laces permit the apparatus to be tightened within a range of 3 inches to adjust it to different circumferences of extremities of different patients; the laces also allow for the expected increase of muscle volume. A universal fit cannot be expected of a simple brace like this, but three apparatus (small, medium and large) will suffice to adequately fit this device to any adult patient.

The two uprights are made of the usual brace steel. A hinged knee joint divides the thigh from the lower leg; the knee lock is of the sliding type,

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* Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. DeLorme, T. L.: Restoration of Muscle Power by Heavy-Resistance Exercises, J. Bone & Joint Surg. **27**:645 (Oct.) 1945.

2. DeLorme, T. L.: Heavy Resistance Exercises, Arch. Phys. Med. **27**:607 (Oct.) 1946. DeLorme, T. L., and Watkins, A. L.: Technics of Progressive Resistance Exercises, ibid. **29**:263 (May) 1948.

3. DeLorme, T. L.; Schwab, R. S., and Watkins, A. L.: The Response of the Quadriceps Femoris to Progressive-Resistance Exercises in Poliomyelitis Patients, J. Bone & Joint Surg. **30-A**:834 (Oct.) 1948. Krusen, E. M.: Functional Improvement Produced by Resistive Exercises of Quadriceps Muscles Affected by Poliomyelitis, Arch. Phys. Med. **30**:271 (May) 1949. DeLorme, T. L., and Watkins, A. L.: Progressive Resistance Exercises in Cup Arthroplasties of the Hip, ibid. **30**:367 (June) 1949.

allowing full range of extension and flexion or locking the knee in complete extension. For the medium-sized apparatus the steel bars measure approximately 10 inches above and 13 inches below the knee joint in length. The bars are spaced at the proximal and distal end of the apparatus by posterior steel bands, 3 inches in width, which follow the curves of an average leg. The apparatus is applied to the extremity by a thigh and a lower leg leather

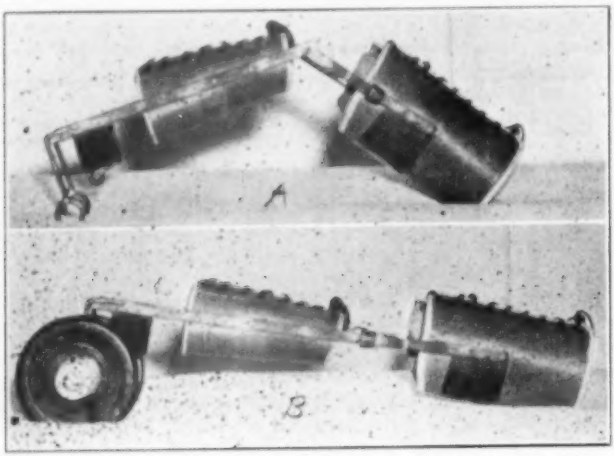


Fig. 1. — Apparatus (*A*) without weights, knee unlocked, and (*B*) with weights applied, knee locked.

cuff, both of which are riveted to the uprights. The thigh cuff reaches downward to approximately 3 inches above the proximal border of the patella, while the lower leg cuff extends upward to the tibial tuberosity.

At the distal end of the apparatus the uprights are bent backward at a right angle and continue in this direction for another 3½ inches. Both ends form a ring permitting the insertion of a metal rod of 1 inch diameter, which is the weight carrier (fig. 1B). In addition, a small ring is welded to the center of the distal posterior steel band for the purpose of attaching weights via a pulley mechanism, as used in connection with DeLorme's exercise table.

In amputations, muscle training is fundamental for developing a useful stump and to assure an optimal gait. The minimum length of an above-knee stump which still allows the successful use of the apparatus is 6 inches. Of course, in thigh amputations the knee joint of the apparatus remains locked for exercises of the hip in all directions. Figure 2 shows an above-knee amputee performing abduction exercises.

Here the patient lies on the side opposite to the amputation. In this position weight resistance in addition to the force of gravity is applied to the tensor fasciae latae and the gluteus medius. For treatment of the hip flexors, such as the iliopsoas, sartorius and rectus femoris muscles, the patient is placed in supine position, while in the prone position extension and hyperextension exercises train the all-important gluteus maximus. Exercising the hip adductors, done by lying on the affected side, is usually less important; this position is awkward, and adductor exercises can more easily be performed with another method, if indicated.

The same hip exercises with a locked knee joint are applicable to below-knee amputations, too. For quadriceps and hamstring exercises the knee joint is unlocked (fig. 3). Extension exercises are done in the sitting position, flexor exercises in the prone position. Maintaining or regaining normal mus-

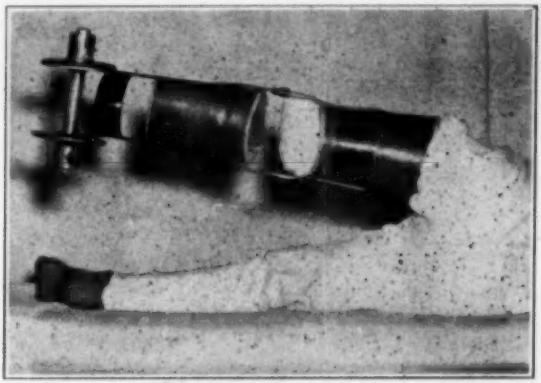


Fig. 2. — Above-knee amputee performing resistance exercises for training in hip abduction.

cle tone and volume will result in faster progress in ambulation training and, when the prosthesis is obtained, in a better gait and in greater endurance.

In amputations the apparatus actually serves only as a device to apply weights to the stump, and the leather cuffs are the means by which the ap-

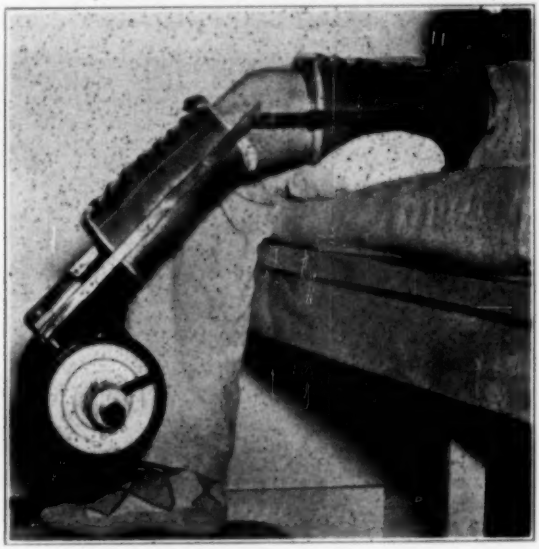


Fig. 3. — Below-knee amputee performing resistance exercises for training the quadriceps group.

paratus is secured in place. In fractures, however, the apparatus braces the fracture site by its uprights and its cuffs. Thus, under such protection progressive resistance exercises can be started earlier than without such a device.

Delayed union is no longer a reason for postponing training of thigh and hip musculature, the latter performed with locked knee joint. Figure 4 demonstrates hamstring exercises against weights in prone position.

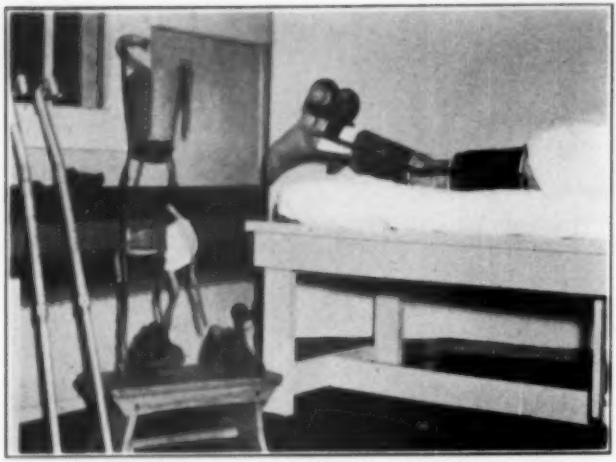


Fig. 4. — Patient with fracture of the shaft of the femur performing resistance exercises for the hamstring muscles.

Of special importance in fractures is a proper, snug fit of the apparatus. This can be accomplished by additional padding underneath the cuffs. With such precautions we have used the apparatus for early rehabilitation of pa-

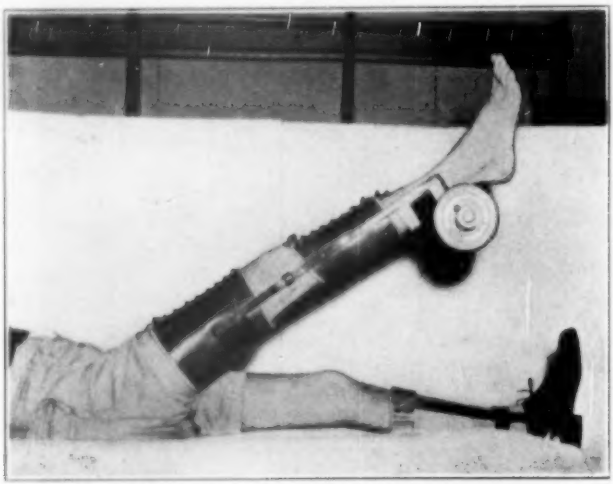


Fig. 5. — Patient with poliomyelitis involving the lower extremities performing progressive resistance exercises for the hip flexors.

tients with fractures of the middle and lower third of the femur as well as with fractures of the lower leg.

In paralytic cases, such as poliomyelitis and peripheral nerve lesions, the apparatus is useful for hip and knee exercises. With flexors and/or ex-

tensors of the knee paralyzed, progressive resistance exercises are carried out by the hip musculature with the knee joint locked (fig. 5). For knee and hip exercises the right angle turn at the distal end of the uprights circumvents the paralyzed ankle, thus eliminating stress and trauma from the muscles of the foot.

The same rationale is valid when the apparatus is used for knee exercises after trauma or surgery, such as tendon transfer, of foot and ankle.

Our system of Progressive Resistance Exercises is the same as described by DeLorme.[4] At the first treatment the muscles or muscle groups to be treated are tested for their 10 repetition maximum (10 r.m.), i. e., the amount of weights the muscle is able to lift through the full range of the joint ten times. After this test, daily treatments are given and the muscles or muscle groups are exercised ten times with 50 per cent of 10 r.m.; after a rest period of two minutes, with 75 per cent of 10 r.m., and, finally, after another pause, with full 10 r.m. The test is repeated in weekly intervals, and the 10 r.m. is increased accordingly. In fractures with evidence of nonunion or delayed union and in the early treatment of fractures with adequate callus formation we have modified the treatment to the extent that weights are used below the 10 r.m. The amount of resistance is selected empirically, depending on the nature of the fracture. The patient is not tested for the 10 r.m., and the maximum resistance used is probably not more than approximately one-half of 10 r.m. It is our policy to be rather conservative and to err on the safe side. Progression of resistance is also intentionally delayed until firm bony union permits the unlimited use of progressive resistance exercises with 10 r.m. However, with observance of these outlined precautions we feel that this type of exercises is safer than the usual hand-resistive exercises, with their undetermined amount of resistance.

It must be realized that the maximum weight load against which the exercises are performed consists of the weights attached plus the weight of the apparatus. Since, however, the weight of the apparatus is constant, we make note only of the additional weights in our therapeutic considerations. We have also used the apparatus for mobilization of contracted knee joints. In this case the weights applied serve the purpose of stretching the contracted tissues. The weights are selected well above the 10 r.m. within the limits of tolerance. No muscular action against this resistance is attempted.

Summary

A specially constructed apparatus is described which is used in connection with progressive resistance exercises for certain indications. Its advantages lie in (1) the protection of recent fractures of thigh and lower leg; (2) the means of applying progressively increasing weights to above-knee and below-knee amputation stumps; (3) the bracing of paralyzed knees for hip exercises, and (4) the elimination of weight from paralyzed or otherwise disabled ankle joints and feet during the application of progressive resistance exercise treatments to hip or knee. The device is simple and can be inexpensively made in any orthopedic brace shop.

We wish to express our appreciation for the cooperation received from the Brace Shop of Cushing Veterans Administration Hospital.

4. Footnotes 1 and 2.

MEDICAL NEWS

Boston Makes History

The first book printed in the United States was printed in Boston, home of the first college, the first subway, and the largest library after the Library of Congress. Here, in the heart of town are buried Revere, Adams and Mother Goose. This was the birthplace of Benjamin Franklin, the Christian Science Church and the first State Medical Society. Beantown, also known as the hub of the intellectual universe was where the Marshall Plan was announced, where Fred Allen was born and where the first Society to bear the name Physical Medicine in this country was founded. Soon it will be known as the site of the biggest and best Convention in the history of the American Congress of Physical Medicine. Write for hotel reservations now. Come a few days early and see where history was made. Bring your family.

New England Society of Physical Medicine

At its annual meeting on May 17, 1950, the New England Society of Physical Medicine elected the following officers: President — Dr. Sidney Licht; First Vice-President — Dr. Manuel Kaufman; Second Vice-President — Dr. Jacob Rudd; Secretary — Dr. David C. Ditmore; Treasurer — Dr. Howard Moore.

Session on Physical Medicine
Medical Society of the State of New York

On May 11 at the Hotel Statler, New York City, the New York Society of Physical Medicine, in conjunction with the Medical Society of the State of New York, presented the following program: "Hydrotherapy in convalescent poliomyelitis," Robert L. Bennett, M.D.; discussion by A. D. Gurewitsch, M.D.; "Modern concepts of diathermy," Jerome Weiss, M.D.; discussion by Richard Kovács, M.D., and "The role of physical therapy in rehabilitation," George M. Raus, M.D.; discussion by William Bierman, M.D., and Michael M. Dacso, M.D.

The Kappa Delta Award for Research in Orthopaedic Surgery

A prize of $1,000.00, donated by the Kappa Delta Sorority, is awarded annually by the American Academy of Orthopaedic Surgeons for the best research done in orthopaedic surgery or a related scientific field by an individual in the United States. The second award, for the year 1950, will be presented at the eighteenth annual convention of the Academy in Chicago, January 31, 1951. Researchers interested in competing for this prize are requested to secure further information from Dr. R. Beverly Raney, Duke Hospital, Durham, North Carolina, Chairman of the Award Committee for 1950.

Dr. Coulter's Books Presented to Northwestern

One of the country's finest collections of books on physical medicine, owned by Dr. John S. Coulter, has been presented to the Northwestern Medical School. The gift will be placed in the Archibald Church Library.

Pennsylvania Academy of Physical Medicine

Dr. Henry Kessler, of the Kessler Rehabilitation Institute spoke on "The rehabilitation of the amputee" at the April meeting of the Pennsylvania Academy of Physical Medicine.

Intensive Course in Cerebral Palsy Offered

A two weeks intensive personal course in Cerebral Palsy is to be given by Dr. M. A. Perlstein at the Cook County Graduate School of Medicine, Chicago, from July 31 to August 12, 1950.

Registration for the course will be by direct application to Mr. James F. Askin, Registrar of the Medical School.

Physical Therapy Scholarship Program

The National Foundation for Infantile Paralysis announces that its Board of Trustees has approved an additional $150,000.00 for continuation of the Physical Therapy Scholarship Program. This action brings to more than $1,950,000.00 authorized since 1942 for such training. More than 1,300 physical therapists have received complete or partial training. In addition, 27 fellowships for preparation as physical therapy teachers have been made. The program will continue to be administered by the National Foundation, with a committee from the American Physical Therapy Association.

Requests for information or applications should be directed to Professional Education Division, National Foundation for Infantile Paralysis, 120 Broadway, New York 5, New York.

Personals

Dr. Peter A. Volpe, disabled World War II veteran who formerly was manager of the Veterans Administration hospital in Dwight, Illinois, has been appointed manager of the VA hospital in Aspinwall, Pennsylvania, VA announced. The appointment became effective April 30.

Dr. Volpe succeeds Dr. Harold R. Lipscomb.

who has been assigned to a position in the Department of Medicine and Surgery in the VA Central Office in Washington, D. C.

Dr. Volpe saw considerable combat action with the Sixth Armored Division in Europe. He entered military service in September, 1942, as an armored medical company commander; became plans and training officer of an armored medical battalion in May, 1943, and was promoted to executive officer of the battalion in November, 1944.

Early in February, 1945, he was in a land mine explosion. His right foot was injured seriously, he lost his right eye, and he suffered multiple fragmentation wounds of the face, right arm and right thigh. He spent nearly a year in Army hospitals, and he finally received a disability retirement as a Major. Dr. Volpe joined VA on August 26, 1946, as chief of the physical medicine rehabilitation section of the former VA branch office in Columbus, Ohio.

Dr. Herman J. Bearzy has been appointed director of Physical Medicine and Rehabilitation of the Ellis Hall Rehabilitation and Convalescent Institute, Philadelphia.

Dr. Michael M. Dacso spoke on "The chronic arthritides rehabilitation and physical medicine" before the Academy of Medicine of the Raritan Bay Area, N. J.

Cedars of Lebanon Hospital, Los Angeles, announces the appointment of Dr. John H. Aldes, as director of Cedars' Department of Rehabilitation and Physical Medicine.

Dr. Louis B. Newman spoke on "Physical Medicine and Rehabilitation of patients with spinal cord injuries" before the Chicago Neurological Society, April 11.

The annual session of the Arkansas Medical Society was held in Fort Smith, April 17-19, under the presidency of Dr. Euclid M. Smith of Hot Springs.

Saturday, April 29th, at the Eastern Section meeting of the Congress, Dr. G. J. F. Barger presented with a plaque by the D. C. Chapter of the American Congress of Physical Medicine in appreciation of his fourteen years of hard work as chairman of that group.

Dr. Robert F. Pitts, professor of physiology at Syracuse University College of Medicine since 1946, will return to the Cornell University Medical College on July 1, to become head of the department of physiology and biophysics and professor of physiology.

Connecticut One State With Plan for Care of Ill and Aged

With the ever-rising age level of the population, state legislative bodies each year are devoting increasing time to the problems of the aged. Despite the enormity of the problem, most are inclined not to face the realities of the situation and to institute temporary measures rather than develop the comprehensive programs that are needed.

One of several striking exceptions to this general trend is the State of Connecticut.

The first step in the program was a two-year study of the situation, in which it was found that while a large number of these older persons were cared for by their families, by personal savings or by private philanthropy, many required public assistance.

Planning on the basis of establishing more dynamic services in existing institutions rather than creating additional facilities, the commission started a pilot demonstration study at the Connecticut State Veterans Hospital and Home at Rocky Hill, which had a new, completely equipped 600-bed hospital.

In addition to a high-level medical program, the hospital has a completely equipped and well-staffed Department of Physical Medicine and Rehabilitation, where patients are given intensive rehabilitation training in self-care. It was recognized that many patients had reached the years where employment after hospital discharge was impossible, but with the training afforded at Rocky Hill, many were able to live full lives of independence at home without becoming burdens to their families. Recognizing that it would be impossible to employ a sufficient number of physicians for specialized medical care, the hospital has followed the plan of the Veterans Administration in developing a highly qualified visiting staff of 115 specialists. — (Rusk, N. Y. *Times.*)

Chester Moses

It is with regret that we announce the death of Chester Moses of Buffalo, New York. Dr. Moses was a member of the Congress for many years.

Training Course in Muscle Reeducation

The Kabat-Kaiser Institute announces a one month training course in the newer technics of muscle reeducation as applied to the treatment of paralysis. Any qualified physical therapist may obtain further information about admission to receive the technical training and arrange for the time to attend the course by writing either to Dr. Herman Kabat, 2600 Alameda Street, Vallejo, California, or to Dr. O. L. Huddleston, 1815 Ocean Front, Santa Monica, California.

Medical Illustrators' Directory Available

The Directory issue of GRAPHICS, the official publication of the Association of Medical Illustrators, contains the name, address, training, professional experience and reference to major published work of each member. Other information pertaining to the profession is included.

The journal, to be issued on June first, will be available to those requiring medical illustration service, and will be sent, free of charge, upon request to the Editor, Miss Helen Lorraine, 5212 Sylvan Road, Richmond 25, Va.

PROGRESS REPORTS

Chest Surgery and "Resistive" Exercise

Veterans Administration disclosed it is using a new and more strenuous type of exercise to prevent deformities in tuberculous veterans who have undergone chest surgery. It is known as "resistive" exercise.

Introduced at the V-A Hospital, Oteen, North Carolina, about three years ago, the results of the postoperative resistive exercise program speak for themselves, according to the V-A Physical Medicine and Rehabilitation Division and TB Division. Skeletal and functional deformities are eliminated or minimized and with arrest of the disease, the patient leaves the hospital to return to a normal productive life in his community.

The study at Oteen also showed that in two surgery groups, one of 80 patients who did not undergo this resistive exercise program, and another of 66 who did the latter appeared to have received better results. In the non-exercise group, only 55.4 per cent of the patients had a negative sputum one year after completion of surgery; in the exercise group, this figure rose to 71 per cent.

Moreover, the study revealed that complications such as wound infection and postoperative spread were likewise less in the exercise group than in the non-exercise group.

"These results have convinced us that resistive exercises can be used in the early postoperative period without fear of harmful effects upon the pulmonary lesion," Dr. J. D. Murphy, Chief of thoracic surgery at Oteen, said. Dr. J. B. Barnwell, Chief, TB Division, and Dr. A. B. C. Knudson, Chief, Physical Medicine Rehabilitation Division, concur in this opinion.

The program begins with the patient's preoperative orientation. This is designed to gain his confidence and give him an understanding of the part he must play in preventing deformity by maintaining a straight spine through his postoperative hospitalization. He is given a basic understanding of the technics of the surgery which will leave an unbalanced condition in the skeletal and muscular structure. This, he is told, will cause his spine to have a tendency to curve, and will also cause other postural deformities.

To offset these deformities, he is shown how certain over-correction measures in bed positioning will be necessary to maintain proper alignment of the spine in the operative area.

Following each surgical stage, as soon as is medically indicated, the over-correction measures are continued and a gradually graded resistive exercise program is begun. This program continues over a period of months.

Beginning with the over-correction measures immediately, the patient is instructed to lie on his side — usually the side on which he was operated — with no support under the head. The spine thus is curved toward the un-operated side and the head toward the operated side. When the patient's condition demands that he lie on his un-operated side, as many pillows as can be tolerated are placed under his head, flexing it laterally toward his operated shoulder.

The patient learns to lie in other positions, too, but the important factor is that he understands he must lie in an over-corrected position as much as possible.

As soon as it is prescribed, massage is used to loosen up the scar tissue which blocks motion of the scapula (shoulder blade). Then come simple exercises, such as pushing back with the elbows against resistance.

To vary exercise, the physical therapist provides enough resistance to test the amount of weight used by the patient to produce a maximum contraction of the muscle. At first the weight is light and is increased at prescribed intervals up to as much as 40 pounds.

Close supervision is maintained at all times by the doctor and the therapist. Pulse and respiration are taken after each exercise period to see that it has not produced too much fatigue. The patient must then practice complete relaxation.

As the patient's condition permits, the exercises become more complex. Exercises involving the legs are started with weights adapted to meet the individual needs of the patient.

But always the emphasis is on correct posture. Even though the instructions are based on over-correction, he must learn to walk properly while observing correct posture.

ARCHIVES of PHYSICAL MEDICINE

OFFICIAL PUBLICATION AMERICAN CONGRESS OF PHYSICAL MEDICINE

∴ EDITORIALS ∴

SHORTAGE OF PHYSICAL THERAPISTS

A note under Current Comment in the recent Hospital Number of the *Journal of the American Medical Association*[1] discusses the shortage of medical technologists, x-ray technicians, physical therapists, occupational therapists and medical record librarians. There have been substantial increases in the number of schools and in the number of graduates in medical technology and x-ray, but the gains in the other technical fields are much smaller.

From 1947 to 1949, the number of physical therapy schools increased from 25 to 31 and the number of graduates from 383 to 469 per year. Three of these schools are operated by the Medical Department of the United States Army. The number of occupational therapy schools remained unchanged at 25 and the number of graduates at 400 per year.

The supply of physical therapists, especially, falls far short of meeting the needs in this field. A rapid count of the total number of registered physical therapists in the United States proper, according to the recently published Registry Directory in the May issue of the ARCHIVES,[2] indicates that there are now 4,636 registered therapists in this country. Fifty-six more registrants are located in Alaska, Canada, Canal Zone, Cuba, Puerto Rico, and other countries over the globe. Addresses of 26 registrants are unknown. California leads other states of the Union in the number of registered physical therapists with 745, New York is second with 618, and Nevada trails with only two.

The combined rated capacities of the civilian physical therapy schools in the United States is 595. The number of graduates in 1949 was 469. It is obvious then that the schools are not filled to capacity and that continued efforts must be made to recruit more students. Some schools have found in recent years that far more men are applying for entrance than women, due, in part at least, to the veterans' educational benefits. The chief effort at recruitment, therefore, should be toward securing more female students. The scholarships offered by the National Foundation for Infantile Paralysis have been exceedingly helpful, but the schools are still not filled to capacity.

As the medical profession recognizes more and more the therapeutic and diagnostic possibilities of the physical procedures, the demand for the services of qualified physical therapists will continue to increase. This, together with the relatively small number of physical therapists that the present schools are able to train, and the loss to the profession by marriage and other factors, makes it appear that there will be a shortage for many years. Such an interesting uncrowded field should attract ambitious young women and young men. More approved physical therapy schools are needed and more intensive recruitment campaign is indicated.

1. Current Comment: Technical Personnel, J. A. M. A. **143**:113 (May 6) 1950.
2. Registry Directory: Arch. Phys. Med. **31**:311 (May) 1950.

THE CONTRAST BATH

One of the most valuable, yet simple, procedures for the purpose of accelerating the local blood flow, especially in the extremities, is the contrast bath. In one of the series of excellent basic physiologic studies on the physical agents coming from the Mayo Clinic, Engel, Wakim, Erickson, and Krusen[1] in the March issue of the ARCHIVES presented an enlightening study on the contrast bath. The paper was read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine in Cincinnati, September 9, 1949. There has been ample clinical evidence of the value of the contrast bath as an enhancer of the peripheral blood flow, but this recent research indicates the rationale of the procedure in a most convincing manner.

The study was done on 51 patients afflicted with rheumatoid arthritis. The patients were divided into three groups: group 1 received contrast baths to the hands and forearms; group 2, to the feet and legs; and group 3, to both upper and lower extremities. The water temperatures were 110 F. (43.3 C.) for the hot and 60 F. (15.6 C.) for the cold. The initial immersion was in the hot water for 10 minutes and was followed by alternating immersions of one minute cold and four minutes hot to a total of 30 minutes. When the upper extremities alone are immersed, the increase in blood flow averaged 95 per cent. When the lower extremities alone were immersed, the average increase in blood flow was 62 per cent. When all four extremities were immersed, the average increase in flow in the upper extremities was 100 per cent and in the lower, 70 per cent.

These increases in blood flow are much greater than those produced by hot packs as determined by Krusen, Wakim, et al.[2] They compare favorably with the increase in blood flow produced by the intravenous administration of typhoid vaccine as presented by Wakim, et al.,[3] but were not as great as the increases produced by the hot tub bath (152 per cent) or the air conditioned fever cabinet (226 per cent) reported by the same authors.

The technic of the contrast is so simple that it can be taught easily to patients and carried out in the home. This feature is important in the home treatment of such chronic conditions as the arthritides, stasis ulcers, and certain of the peripheral vascular diseases. The contrast bath is also useful in the convalescent care of fractures, sprains, contusions, and in the treatment of selected acute and chronic local infections.

The optimal time factors in the administration of the contrast bath have been the subject of some discussion and investigation. Woodmansey, Collins, and Ernst[4] found the optimal immersion times and temperatures for English patients to be six minutes at 41.6 to 45 C. (107 to 113 F.) for the hot water and four minutes at 8.3 to 15.5 C. (47 to 60 F.) for the cold. Krusen[5] on the other hand, found the optimal immersion times for American patients to be four to five minutes for the hot water and one to two minutes for the cold. He suggested that the difference in findings might be due to the fact that the English maintain their living quarters at lower temperatures than do we. The alternate hot and cold immersions may be continued 20 to 30 minutes or more as indicated in the individual case and the whole procedure may be repeated as frequently as seems necessary. The writer has used the con-

1. Engel, J. P.; Wakim, K. G.; Erickson, D. J., and Krusen, F. H.: The Effect of Contrast Baths on the Peripheral Circulation in Patients with Rheumatoid Arthritis, Arch. Phys. Med. 31:135 (Mar.) 1950.
2. Krusen, F. M.; Wakim, K. G.; Leden, U. M.; Martin, G. M., and Elkins, E. C.: Effect of Hot Packs on Peripheral Circulation, Arch. Phys. Med. 31:140 (Mar.) 1950.
3. Wakim, K. G.; Krusen, F. H., and Elkins, E. C.: Effects of Artificially Induced Fever on the Circulation in Arthritic Patients, Arch. Phys. Med. 29:274 (May) 1948.
4. Woodmansey, A.; Collins, D. H., and Ernst, M. M.: Vascular Reactions to the Contrast Bath in Health and in Rheumatoid Arthritis, Lancet 2:1150 (Dec. 16) 1939.
5. Krusen, F. H.: Physical Medicine, Philadelphia, W. B. Saunders Company, 1941, p. 504.

trast bath, with good effect, as often as every three hours in the treatment of certain acute local infections.

The physician must not be deceived by the simplicity of the contrast bath. It is a potent stimulator of local blood flow and is useful in almost any condition where such an effect is desired. If the reader has not perused the article by Engel, Wakim, Erickson, and Krusen[1] in the March (1950) issue of the ARCHIVES, he should, by all means, do so.

THE EASTERN SECTION MEETING

The Eastern Section meeting of the American Congress of Physical Medicine, held on Saturday afternoon and evening, April 29, 1950, in Washington, D. C., was exceedingly well attended from all parts of the East — Boston to Richmond — the total number of persons registered being near 150. The afternoon session was held at the George Washington University Hospital and preceded by an inspection of the well equipped, spacious and well placed Department of Physical Medicine, under the direction of Dr. Charles S. Wise, who also acted as Chairman of the Local Committee. The afternoon's papers, all clinical, were given by three members of the faculty of George Washington University and two of Georgetown University and discussed by members of the Congress; they included the relation of physical medicine to rehabilitation after chest surgery, to peripheral vascular disease, to neurologic conditions, fractures at the elbow and rheumatoid spondylitis. The evening session began with an excellent dinner served at the Hotel Willard, at the close of which greetings were given from the chairmen of the component societies. A panel-symposium on the shoulder, including functional anatomy, orthopedic aspects and physical medicine, was the evening's topic ably conducted by Dr. William H. Schmidt. All these presentations and their discussion were of high order and moved promptly on schedule. The meeting unquestionably made many new friends for physical medicine at the nation's Capitol and offered those in attendance an instructive although strenuous afternoon and evening, as well as a welcome opportunity for a pleasant social time. Credit for the excellent planning and carrying out of the program is due to the Chairman, genial Col. Emmett M. Smith, Chief, Physical Medicine Consultants Division, United States Army Medical Department, and to the Secretary, dynamic Dr. Herman L. Rudolph of Reading, Pa., as well as to the members of the Washington Committee.

BOOK REVIEWS

METHODS IN MEDICAL RESEARCH. Volume 2. *Julius H. Comroe, Jr.*, Editor-in-Chief. Cloth. Price, $6.50. Pp. 301 with illustrations. The Year Book Publishers, Inc., 300 E. Illinois St., Chicago 11, 1950.

This is the second volume of the very important series of Methods in Medical Research published under the auspices of an editorial committee consisting of Drs. Irvine H. Page, A. C. Ivy, Colin M. MacLeod, Carl F. Schmidt, Eugene A. Stead and David L. Thomson. It contains, as did the first volume, methods in certain fields of medicine. The same excellent procedure has been followed in which the paper written by one writer is followed by comment by others with experience in the same field.

Three large classifications are discussed in this volume: (1) Methods of Study of Bacterial Viruses; (2) Pulmonary Action Function Tests, and (3) Assay of Hormonal Secretions.

Specialists in physical medicine would usually not be much concerned with the study of bacterial viruses. It is, however, extremely interesting to read the methods used in virus study, particularly to those interested in infantile paralysis. One would get a good impression from this book of the extreme complexity of some of the methods used in virology.

The second main division, Pulmonary Function Tests, is, of course, of extreme importance to the physiatrist. Under the able direction of Dr. Comroe, a superior review has been produced. The characteristics of different types of mouthpieces and masks are discussed and the technic of bronchial spirometry is described. Different valves used in respiratory experiments are discussed.

The chapter on Bronchial Spirometry, by Dr. Wright, from Saranac Lake, is of particular importance. Those are physical procedures that lend themselves very well to clinical diagnostic application, and the physiatrist should undoubtedly be interested in them. The different types of spirometers for measurement of gas volume are then discussed.

The next chapter deals with the pneumotachograph. This device is used to record the instantaneous air flow to and from the lungs. Obviously, a very important section is devoted to the measurement of the composition and the chemical analysis of the respired gases. Different methods of sampling are discussed, and the reader will find an excellent review of the different available methods of gas analysis both chemical and physical.

Among the physical methods can be mentioned the measurement of thermoconductivity of a gas and measurement of the refractive index, and particularly the magnetic susceptibility or the so-called Pauling oxygen meter, which depends on the paramagnetic property of oxygen while the other gases are diamagnetic.

Infrared absorption and electrical emission spectrums are also used in the physical analysis of the respiratory gases, as is the mass spectrometer.

Obviously the measurement of oxygen in the respiratory gases is followed by measurement of the arterial blood. The Technic of Arterial Puncture is described by Comroe. One would find in this very short but very adequate chapter enough to start experimental work in this field. The chemical and physical methods for analysis of the blood gases, oxygen and others, are discussed.

There is in this book a very good discussion of the oxymeter, that is, the photoelectric method of measuring oxygen. The Millikan oxymeter has made oxygen methods clinically practical, and its modern variation has contributed to the effectiveness of this method. One finds in this book a discussion of the oxymeter and a critical analysis of its value which should be read by everybody interested in the treatment of patients with bulbar poliomyelitis. One would also find the instrument of Wood which gives an absolute recording of arterial oxygen saturation. Other methods of oxygen determination are also discussed.

Apart from the oxygen saturation, a very important property to be measured is the blood oxygen tension, and again different methods are exhaustively described and discussed.

It should be obvious from this that the value of this book goes far beyond the simple processes of measurement of pulmonary ventilation. The latter part of this section of the book is devoted to measurements of respiratory capacity, maximum breathing capacity, and instantaneous air flow.

A particularly important chapter is the chapter on the Measurement of Alveolar Air. This chapter contains comments from laboratories other than those responsible for the original article. These are an extremely valuable addition.

The third section of the book is devoted to the Assay of Hormone Secretion. Many of the Hormone Evaluations are not of immediate application to the field of physical medicine, but the reader will find an extensive analysis of the methods of assay of adrenocorticotrophic hormones and different methods which are related to the presently so important 17-ketosteroids.

This book is again extremely valuable as an orientation in research methods. For the research worker, who for his work needs an understanding of the methods of an allied field, the value of these books cannot be overestimated. It should be in the library of every research worker, and every specialist in physical medicine who expects to apply the methods of modern medical research intelligently to clinical problems.

ANNUAL REVIEW OF PHYSIOLOGY. Volume XII. By *Victor E. Hall*, Editor, Stanford University, *Jefferson M. Crismon*, Associate Editor, Stanford University, and *Arthur C. Giese*, Associate Editor, Stanford University. Fabrikoid. Price, $6.00. Pp. 609. Annual Review, Inc., Stanford, California, 1950.

The twelfth volume of the "Annual Review of Physiology" meets fully the expectations set by preceding volumes. For the first time since the World War II those asked to contribute chapters were able to do so, and so it would seem that at last the tremendous demands made on scientific workers by the late war have now subsided somewhat. A novel innovation, and a good one, in this volume is the introduction of a "Prefatory Chapter." This chapter has been written by Eugene Du Bois on "Fifty Years of Physiology in America." It is written from the viewpoint of a man trained first in medicine, then diverted into pathology, pathologic physiology, physiology nutrition, private practice, academic medicine, military medicine and, finally, the teaching of physiology to medical students. De Bois states that it is physiology which binds together the medical sciences. This chapter shows the writing of a man of wisdom and excellent insight; it is well written and an outstanding contribution. This prefatory chapter is to be a feature of future editions, but it will be most difficult to meet the high standards set by Du Bois.

Edelmann, of the Brookhaven National Laboratory, reviews the uses of radiation in biologic research and therapy. The material reviewed is from July, 1948 to June, 1949. The reviewer, however, feels that the microwave radiation at the 10 cm. wavelength definitely does not carry the same hazard as x-rays, alpha rays and neutrons, as inferred by Edelmann. Owing to the present interest in radiation to both the physician and the general populace, this chapter makes very profitable reading.

The subject of growth has been well reviewed by Zamecnik and Aub, of Harvard. The review is concerned with that practice of the field which bears on protein metabolism and which was published during 1948 and up to July, 1949. The reviewers state they have been impressed by the increase in mingling and merging of traditionally separate disciplines in recent investigations on the problem of growth. They point out that as the living organism increases in complexity so necessarily do the mechanisms which control and regulate its orderly growth. To describe this over-all concept, the new word "cybernetics" has been coined.

Physiatrists will be especially interested in the chapter by Hardy, of Cornell, who reviews the physiologic responses to heat and cold.

The peripheral circulation is reviewed by Edholm, of the University of Western Ontario. The newer technics for measuring arterial pressure in man is well covered.

Other equally absorbing topics are the physical properties of protoplasm, physiologic genetics, physiology of supporting tissue, water metabolism, respiratory system, digestive system, coagulation of blood and hemostasis, blood gas transport, energy metabolism, heart, kidney, conduction and synaptic transmission in the nervous system, somatic functions of the nervous system, visceral functions of the nervous system, physiology of smell, physiology of vision, metabolic functions of the endocrine glands and reproduction.

Each chapter is a review by a recognized specialist in that particular field. It is no small task to select the cream of the literature, and it is surprising to find it done so well. No matter what one's interest may be in medicine, one is sure to find valuable material in this volume.

This book is highly recommended.

DISEASES OF THE FOOT. By *Emil D. W. Hauser*, M.S., M.D., Associate Professor of Bone and Joint Surgery, Northwestern University Medical School. New, Second Edition. Cloth. Price, $7.00. Pp. 415, with 195 illustrations. W. B. Saunders Company, Philadelphia and London, 1950.

That Hauser's "Diseases of the Foot" met a real need is evident by the publication of the second edition. This second edition is most welcome. The author stresses the theme throughout the entire book that function is the primary consideration of treatment. The treatment of pes valgoplanus with corrective shoes and correct gait was so well received that the author decided to rewrite the chapter giving more detailed illustrations for greater clarity.

Hauser has included the treatment in infancy of congenital talipes equinovarus and congenital pes valgoplanus with cohesive bandage; an ambulant brace for maintaining overcorrection of the club foot until muscle balance is established; as well as technical improvements in the surgical correction of hallux valgus, hammer toe, and metatarsalgia.

The chapter on infections now includes the current use of antibiotics.

Advances made during the late war in the treatment of circulatory disturbances are discussed. A new and effective method for treatment of chronic thrombophlebitis, using anticoagulants and antibiotics is presented in detail.

Physical therapy treatment is outlined wherever the author believes it to be indicated, and is well and adequately presented.

In every sense of the word this is a most practical book for the physician. The book is well written and the subject matter ably presented. The publisher, too, has published a work worthy of his art. This volume should be in the library of every physiatrist and physical therapist. It is highly recommended.

OCCUPATIONAL THERAPY. PRINCIPLES AND PRACTICE. Edited by *William Rush Dunton, Jr.*, M.D., Founder and Former Editor, *Occupational Therapy and Rehabilitation*, and *Sidney Licht*, M.D., Editor, *Occupational Therapy and Rehabilitation*. Cloth. Pp. 321. Price, $6.00. Charles C Thomas, Publisher, 301-327 E. Lawrence Ave., Springfield, Illinois, 1950.

Occupational therapy is now an accepted part of medical therapeutics for a wide variety of conditions. To be properly utilized, however, the physician who prescribes occupational therapy must have an intimate knowledge of the principles involved and a general familiarity with technics. In the past this knowledge could be obtained only through observation and scattered reading. This book written by and for physicians is a timely one and should be required reading for all physiatrists and available to others less closely connected with the prescription of occupational therapy.

The authors are exceptionally well qualified to present both theoretical and practical aspects. Special sections deal with occupational therapy for psychiatric disorders, amputees, and in heart disease, tuberculosis and cerebral palsy. Related activities discussed include education in the hospital, bibliotherapy, drama therapy and recreation.

In spite of this broad coverage there are certain topics which might be dealt with in more detail which would add to the value of the book. Specific conditions such as arthritis, burns, and trauma including fractures often require special modifications of technics which could be enlarged upon. It would also be of value to have detailed information on organization of a department in a hospital and rehabilitation center including equipment needs, also integration with other rehabilitation procedures including vocational testing and training and relation to future employment. It might be helpful to the reader to have explained what an occupational therapist is by educational background and training, so that the physician may place her correctly in the total scheme of treatment. These suggestions are made with an eye to future editions. The present book is an excellent one, deserving wide circulation and use among physicians in hospital practice.

PRACTICAL ORTHOPTICS IN THE TREATMENT OF SQUINT (AND OTHER ANOMALIES OF BINOCULAR VISION). By *T. Keith Lyle*, M.A., M.D., M. Chir., Surgeon and Medical Officer in Charge of Orthoptic Department at the Westminster Branch of the Moorfields, London, and *Sylvia Jackson*, S.R.N., D.B.O. With the assistance of *Lorna Billinghurst*, D.B.O., Orthoptist, Addenbrooke's Hospital, Cambridge, Eng., and *Diana Salisbury*, D.B.O., Senior Orthoptist, Westminster Branch of Moorsfields. Third edition. Cloth. Price, $8.50. Pp. 271, with 152 illustrations. The Blakiston Company, Division of Doubleday & Company, Inc., 1012 Walnut St., Philadelphia 5, 1949.

This excellent book covers the field of orthoptics with admirable clarity and completeness. A brief historical and physiologic introduction is followed by chapters on strabismus, abnormal retinal correspondence and heterophoria, with details of etiology and treatment. There is a wealth of good illustrations, a glossary far superior to the usual perfunctory word lists, a short bibliography, and an index. This third edition shows every indication of conscientious work by the collaborating authors and is to be recommended to everyone interested in problems of orthoptics.

HEALTH EDUCATION IN ELEMENTARY SCHOOLS. ACTIVITIES, MATERIALS, METHODS. By *Helen Leslie Coops*, Ph.D., Health Coordinator and Associate Professor of Physical and Health Education, University of Cincinnati, and Consultant in Health Education, Ohio Department of Health. Cloth. Pp. 279. Price, $3.50. A. S. Barnes & Company, 101 Fifth Avenue, New York 3, 1950.

Recommended as a sound, up-to-date, and practical guide for use in elementary schools and by parents and physical education students.

STUDIES IN AIR HYGIENE. By *R. B. Bourdillon*, and others. Medical Research Council Special Report Series No. 262. Paper. Price, 7s. 6d. Pp. 356, with 104 illustrations. His Majesty's Stationery Office, York House, Kingsway, London, W.C. 2, 1948.

Recognizing that the outbreak of the war in 1939 increased the danger of epidemic disease, a team of workers was organized at the National Institute for Medical Research by the Medical Research Council in London for the purpose of studying "airborne" infections. From then on until the end of the war, research on air hygiene was pushed by this organization with varying personnel and leadership, and the present volume is a collection of reports of their work. While it is neither an introduction nor a comprehensive treatise, the reports cover, by a sort of sampling process, most of the vexing problems in this broad field. An extraordinary amount of detail of results and procedure is included in this volume, and will make it priceless to all future investigators of air hygiene. Practical problems are kept in view throughout (air contamination in a cruiser, ventilation of an operating amphitheater, effectiveness of hypochlorous acid in air raid shelters, propylene glycol as an air disinfectant, ultraviolet light barriers, etc.) and well-chosen photographs illustrate some of the situations studied. The book should be called to the attention of every bacteriologist, epidemiologist and ventilating engineer. The excellent table of contents compensates somewhat for the absence of an index.

PHYSICAL MEDICINE ABSTRACTS

Hazards of Intense Sound and Ultrasound. Hallowell Davis; Horace O. Parrack, and Donald H. Eldredge.

Ann. Otol., Rhin. & Laryng. **58**:732 (Sept.) 1949.

Ultrasonic vibration, usually shortened to "ultrasonics," refers to sound waves at frequencies above the upper limit of human hearing. The American Standards Association sets 15,000 cycles per second as the arbitrary dividing line. Sound waves at ultrasonic frequencies differ particularly from audible sound waves in their shorter wave length, in forming relatively sharp sound shadows, and in being attenuated more rapidly as they travel through air.

Ultrasonics in nature are relatively weak. Familiar man-made sources are the jingling of small pieces of metal, such as a bunch of keys, and, of more practical importance, the escape of compressed air, the acrodynamic noise of aircraft and the exhausts of jet engines and rockets. It is with the development of the latter to their present tremendous power that ultrasonics have become a matter of practical concern to the otologist and the flight surgeon. Are these high-frequency, high-intensity vibrations a threat to the ear, or to any other organ of the body? And if the ultrasonics are harmless, what about audible sound at the very high intensity levels of 150 db or higher that have been measured near certain modern power plants for airplanes?

Present evidence does not indicate that airborne ultrasonic vibrations constitute a practical hazard to hearing or produce any specific effects on the nervous system or sense organs. In general it is high intensities that are potentially hazardous, not high frequencies as such. Sounds above 120 db stimulate the sense of touch and may cause temporary and possibly permanent hearing loss. Levels above 140 db are painful to the ear and exposures to such levels without special protection should be avoided.

A frequency of 6500 c.p.s. at 159 db caused nearly intolerable pain to one subject and ruptured his ear drum during a five-minute exposure. Some high-tone hearing loss above 10,000 c.p.s. persisted after 14 weeks.

The vague subjective feelings of fatigue, annoyance, irritation, etc., induced by very intense sound or vibration may represent nature's first warning of the presence of a stress that is not yet severe enough to cause more objective manifestations.

Flexor Tendon Injuries of the Hand. Albert T. Hays.

Minnesota Med. **32**:1199 (Dec.) 1949.

Lacerations of the hands are common injuries. They are the most frequent household injuries and the most common industrial injuries. The more serious ones must be recognized at the time of the injury in order that the proper treatment may be started.

The splint is removed at the end of three weeks and hot soaks of the hand begun with guarded active movements. The splint is reapplied at night. At the end of four weeks, active physical therapy is begun with whirlpool, massage, active and passive movements and muscle training.

The Influence of "Red Light" and of "Ionization" Upon the Penetration of the Skin by Penicillin. Morris Cutner.

Brit. J. Phys. Med. **12**:144 (Nov.-Dec.) 1949.

In this paper the term "ionization" is used to denote the application of penicillin by means of a pad soaked in a solution of penicillin in doubly-distilled sterile water, through which a galvanic current is applied, as in iontophoresis with inorganic substances. By "red light" is meant the luminous and short infrared rays obtained by filtering radiant heat filtered through ruby red glass.

The patient presented a typical paronychia, swollen, tender and painful, also an axillary adenitis. Time was of great importance and it was essential that an incision should be avoided if at all possible. Penicillin injections were absolutely refused.

The finger was therefore exposed to "red light" for thirty minutes, and the paronychial area was then subjected to anodal ionization with a penicillin solution (15,000 units per millilitre) under aseptic conditions. A current of 5 milliamperes was passed for thirty minutes.

Investigations were therefore carried out to determine which of these factors — the red light, the anodal galvanism, or the combination of the two — contributed to the good result obtained from the penicillin, or whether any one of them was really contributory.

Aqueous solutions of penicillin are not capable of ionization by the galvanic current in amounts sufficient to have any useful effect. Penicillin cannot be driven into the skin by means of the galvanic current with the use of pad electrodes. Penicillin solutions in contact with the unbroken skin at body temperatures do not penetrate it or undergo absorption in measurable amounts. The application of red light to an area of skin for thirty minutes, at an intensity of maximum toleration, renders it capable of absorption of penicillin from a penicillin-solution compress to a demonstrable therapeutic level. The combination of red light and a penicillin compress affords an effective means of dealing with local sepsis.

Rehabilitation of Miners. S. Bridge Davis.

Brit. J. Phys. Med. 12:139 (Nov.-Dec.) 1949.

Treatment is carried out by regulated and graduated exercises in the gymnasium, with or without apparatus; physical therapy, including massage, heat treatment and the use of electricity to stimulate weakened muscles and stiff joints; team games, outdoors as well as indoors; occupational therapy.

Injuries and infections of the hands, and especially partial paralysis of the fingers as a result of nerve injuries, require a special technic. Special forms of physical therapy (for instance, heat, galvanism and wax baths), followed immediately by finger exercises, are used for these patients, together with light occupational therapy to promote frequent and gentle movement of the fingers and hands. Sewing and knitting, net-making and weaving, leather work, stool-seating and basketry, clay modeling and painting — these are some of the many occupations which help to rehabilitate a weak and injured hand. Light metal work, in the assembling of small parts, is also excellent and popular for this purpose.

Pain in Peripheral Vascular Disease. A. J. Slessor, and James Learmonth.

Practitioner 163:445 (Nov.) 1949.

Pain, the most common symptom of peripheral vascular disease, is due in almost every instance to ischemia. This article is concerned primarily with obliterative arterial disease.

Various types of postural exercises have been used, the most popular being known as the Buerger-Allen exercises. The limbs are elevated to 45 degrees until full blanching has occurred in the feet; the legs are held dependent until full rubor develops; non-weight-bearing foot exercises are performed for two minutes. Each cycle lasts for about four minutes, and six cycles comprise one session, of which three should be performed daily. The refilling of the dependent limbs with fresh arterial blood aids nutrition, and the gentle exercises act as a mild stimulus towards the development of a collateral supply, as well as in maintaining muscle tone. Postural exercises are useful for rest pain and for early ulceration or gangrene; if pain is increased, it may be inadvisable to persist with them.

Ultraviolet Blood Irradiation Therapy (Knott Technic) in Thrombophlebitis. G. P. Miley, and P. M. Dunning.

Am. J. Surg. 68:892 (Dec.) 1949.

Since the first report on the use of ultraviolet blood irradiation therapy in thrombophlebitis was published, the authors have used this method in an additional eighteen cases of thrombophlebitis; of these eighteen, ten were acute and eight chronic.

In eighteen consecutive instances patients with acute or chronic thrombophlebitis were given ultraviolet blood irradiation therapy (Knott technic).

In the ten acute cases there was a rapid subsidence of pain and tenderness within twelve to forty-eight hours. Fever, when present, returned to normal within forty-eight hours and the edema usually disappeared by the twelfth day.

In the eight chronic cases the symptoms also disappeared but over a generally longer period of time, depending on the duration of the disease process prior to treatment.

There were no noticeable untoward effects either immediate or delayed.

According to the authors the Knott technic of ultraviolet blood irradiation has been found a safe and efficient method of controlling acute and chronic thrombophlebitis.

Emotional Adjustments for the Handicapped. William C. Menninger.

Crip. Child. 27:4 (Dec.) 1949.

No one who has worked or lived with a physically handicapped person can be unaware of the emotional load created by the crippling.

If we are going to understand adequately the reactions of the physically handicapped individual, we must start with a clear understanding of ourselves. Whatever his reaction may be depends very largely on our reactions to his problem.

The common emotional feelings about physically handicapped persons, with their resulting reactions are: Curiosity, pity, over-solicitousness, repugnance, fear, sympathetic understanding.

At times everyone feels some insecurity as to whether or not he is or will be accepted, whether or not he is or will be liked. In the handicapped person all of these insecurities are or may be greatly increased. He is acutely sensitive to the fact that he is "different" and thus does not have an even chance to be accepted or approved or liked.

Rehabilitation of the physically handicapped can only be achieved through the contributions of many people with different skills from many different disciplines.

The emotional problems of any handicapped individual may be more important impediments to his rehabilitation than are the physical factors. All must remember that the body is only the house in which a person lives and his happiness need not be dependent upon its perfection or luxury.

The reality of the situation must be accepted.

Focal Neurological Lesions Produced by Microwave Irradiation. W. H. Oldendorf.

Proc. Soc. Exper. Biol. & Med. 72:432 (Nov.) 1949.

Adult rabbits weighing about three Kg. were utilized. Under intravenous pentothal anesthesia sufficient to immobilize the animal, the animal's head was placed on a wooden block approximately seven cm. in thickness. The area of the scalp over the proposed site of irradiation was shaved. A thin copper shield with an oval hole 2 by 3 cm. was then placed with the long axis of the

hole parallel to the rabbit and over the proposed site, in the present cases the right cerebral hemisphere. It was found convenient to braze a guide on the upper surface of the shield to maintain the intersection of the lead-in conductor and dipole directly over the hole in the shield. In the "C" type of director, which was used throughout, the point of maximum radiation was directly underneath the small screw which held the dipole in place.

A technic is described of producing focal lesions in the cerebral cortex of rabbits by microwave irradiation without incising the scalp or skull. The results on two animals are reported and future possibilities of this work are discussed.

Clinical Management of the Patient with Fatigue and Nervousness. Dwight L. Wilbur.

J. A. M. A. **141**:1199 (Dec. 24) 1949.

Patients with chronic fatigue and nervousness plague every practicing physician. They usually present a relatively simple diagnostic but a difficult therapeutic problem, although at times the diagnosis also may be difficult.

Certain general hygienic measures are useful in the management of chronic fatigue and exhaustion.

Rest is an extremely important therapeutic measure for the exhausted person who is not too upset emotionally. This rest may be simply relaxing in a chair, lying on the bed or sleep.

Regular physical exercise of a type which can be followed for years and which is pleasant for the patient is often helpful in overcoming fatigue and tension. Exercise which requires companionship and not just solitary effort is desirable unless the spirit of competition is so strong that the patient becomes as tired over his play as over his work. Similarly, recreation in forms which appeal to the patient may partially or completely meet his needs.

The responses to physical therapy vary. In general, heat and massage are relaxing, but an occasional tense or anxious patient cannot tolerate them or is made worse by them. While these methods of treatment are expensive if long continued, short courses at the onset of treatment or during a "crisis" may be valuable. As Alvarez has well expressed it, for some patients physical therapy is helpful because it gives the patient something to think about, something to do, someone to talk to and something to look forward to. Swimming may be helpful if it is available and tepid baths at bedtime often help produce relaxation and sleep.

Achieving Goals Through Research in Physical Medicine and Rehabilitation. Frank H. Krusen.

Crip. Child. **27**:10 (Dec.) 1949.

New goals in the care of disabled children and adults are best achieved by a joint development of service, education and research. Chronologically the espousal of research may come last but, in importance, it comes first. Effective research is best achieved by close teamwork between the laboratory worker and the clinical worker. The real advances and improvements in caring for our disabled citizens will come through an ever-expanding program of good combined laboratory and clinical research.

Ultrasonic Wave Therapy. U. Hintzelmann.

J. A. M. A. **141**:1192 (Dec. 17) 1949.

Niemoller discusses the various frequencies and wattages employed for ultrasonic wave therapy and reports his experiences with this form of therapy over a period of fourteen months in which a total of 679 treatments were given to 120 patients. Favorable results were obtained in patients with gastroduodenal ulcers, crural ulcers, sciatica and other forms of neuritis, in a case of trigeminal neuralgia, in patients who had sustained contusions, in muscular dystrophy and in humeroscapular periarthritis.

Suction Socket Prosthesis for Above-Knee Amputees. Augustus Thorndike.

Am. J. Surg. **68**:603 (Nov.) 1949.

A prosthetic device first patented by Dubois Parmalee of New York in 1863 has again attracted the attention of the medical profession.

The tentative conclusions on the current experimental use of the suction socket above-knee prosthesis are as follows: The suction socket above-knee prosthesis is described and found to have been fitted to 211 veteran amputees. Complete failures represent 4.3 per cent of the patients.

Inasmuch as 58 per cent of the patients have been wearing this prosthesis for four months or less, the favorable results cannot be construed as conclusive evidence for general approval of the suction socket prosthesis.

Technic of Peripheral Nerve Surgery. R. Glen Spurling.

Minnesota Med. **32**:1096 (Nov.) 1949.

These lesions are so relatively infrequent in civilian life that no single individual can hope to accumulate enough data to change radically the present concepts which have been tested upon many thousands of cases.

The operation is but a single phase of the treatment of an extremity paralyzed as the result of a peripheral nerve injury. An extremity will be functionally useless, however satisfactory the nerve repair and subsequent regeneration may be, if temporarily denervated muscles are permitted to become irreversibly atrophied or fibrosed, or if the joints of the wrist, hand, ankle or toes are "frozen" beyond repair. For the best results it is essential that physical therapy be employed both before and after operation.

Recent experiments and clinical studies have indicated that daily galvanic stimulation of denervated muscles will prevent atrophy and retard fibrosis. This measure was employed as a routine in all cases, beginning with fifteen brisk contrac-

tions daily and progressing gradually to thirty contractions. When casts were used for postoperative immobilization, windows were cut over the bellies of the paralyzed muscle groups and galvanic stimulation was begun the day after operation. Other measures included massage, active and passive motion and the use of dry and moist heat as indicated. Particularly careful attention was given to the active and passive motion of small joints. Fixation by splints was kept at a minimum, detailed instruction of the patients in respect to the care of their own joints was considered more important than mechanical methods of fixation.

Management of Post-Operative Pulmonary Complications. H. Erhoo.

Manitoba M. A. Rev. 29:273 (May) 1949.

Of all the complications that beset the surgeon, those involving the lungs are among the most common. These complications, marking the difference between success and failure of an operation have led to more intelligent efforts in their reduction by better preoperative preparation, improvement in anesthetics and their administration, meticulous care in the elimination of operative trauma and close attention to the patient throughout the convalescent period. The sensible approach to pulmonary embolism is prevention of phlebothrombosis. This may be accomplished through early rising, by exercise, Trendelenburg position to accelerate venous return from the extremities, anticoagulants, prevention and correction of dehydration and circulatory collapse and deep breathing to increase negative thoracic pressure and hence favor the movement of venous blood.

Effect of Adrenergic Blocking Agents on the Cutaneous Action of Epinephrine (17349). Jules H. Last; Arthur Rodriquez, and Isadore Pitesky.

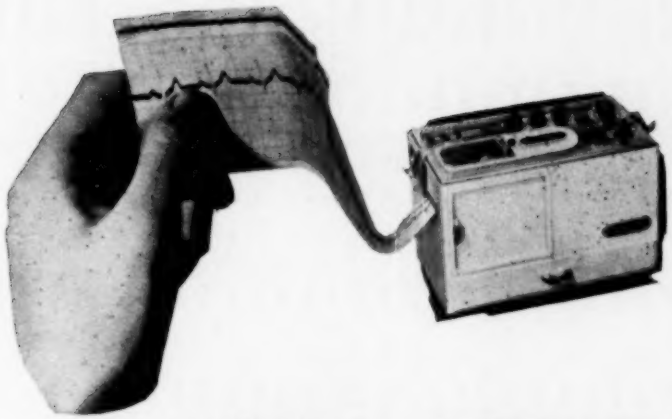
Proc. Soc. Exper. Biol. & Med. 72:114 (Oct.) 1949.

Adrenergic blocking drugs are of clinical interest in the treatment of conditions characterized by the element of vasospasm, such as early Buerger's disease, Raynaud's disease and causalgic states. It was felt that by the direct diffusion or by ion transfer through the skin, it would be possible to avoid the generalized toxic manifestations encountered by way of the parenteral route. The adrenergic blocking agents selected for this study were N-(2-chloroethyl) dibenzylamine hydrochloride (Dibenamine) introduced by Nickerson and Goodman and N-(2-bromoethyl)-N-1-naphthalenemethylamine hydrobromide (SY-28) introduced by Loew and Micetich. Prior to application in the human, data were obtained in a group of albino rabbits. Both Dibenamine and SY-28 were absorbed by the intact rabbit skin and were capable of blocking the vasoconstriction produced by intracutaneously administered epinephrine. By this route SY-28 was approximately 5 times as potent as Dibenamine. When administered by ion transfer, the penetration of both drugs into the skin was significantly facilitated, both blocking compounds were fixed locally in the skin. Contiguous untreated areas were still capable of responding to epinephrine. By the intravenous route, SY-28 was approximately 8 times as potent as Dibenamine. The "epinephrine reversal" phenomenon has been noted for the first time in the skin of the rabbit and suggests the presence of vasodilator fibers.

Outbreak of Poliomyelitis in Canadian Eskimos in Wintertime; Epidemiological Features. A. F. W. Peart.

Canad. J. Pub. Health 40:405 (Oct.) 1949.

The epidemic described by Peart consisted of two separate outbreaks. The first may be traced back to July, 1948, at which time an Eskimo and an Indian girl developed paralytic poliomyelitis. These persons lived just north of Churchill. Early in September, 1848, an Eskimo named Tutu, while returning from Churchill to Pistol Bay, visited many camps en route, in the neighborhood of Nunella and Eskimo Point. During the first week of October, 2 cases of paralytic poliomyelitis developed at Nunella and 3 at Eskimo Point, all of which were in camps visited by Tutu. One of those attacked was a missionary. Another victim at Eskimo Point was a constable who three weeks later, although paralyzed in one extremity, proceeded to Padlei. During the latter part of December, 7 paralytic cases developed at Padlei, resulting in 2 deaths. All of these cases were from camps visited by the constable. The second and more extensive outbreak of the epidemic developed at Chesterfield Inlet after the visit, on Jan. 28, 1949, of another missionary from Eskimo Point. This man resided at the hospital and visited the patients in the hospital as well as the inmates of the Industrial Home. He also visited the population in the settlement and finally returned to Eskimo Point. There is no doubt that this missionary had visited the poliomyelitis victims at Eskimo Point before his trip to Chesterfield. On February 14, the first case of poliomyelitis developed at Chesterfield Inlet, and within seventeen days 54 paralytic cases, with 14 deaths, had occurred. This epidemic demonstrated that poliomyelitis can appear in epidemic proportions even in extremely cold climates and suggests that the immunity of the population is probably a more important factor in the control of poliomyelitis than climatic changes.



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Baruch Center of Physical Medicine of the Medical College of Virginia, in affiliation with Richmond Professional Institute, Richmond[1]	Walter J. Lee, M.D. Miss Suzanne Hirt	H.S.-a-b-c-d-e	1-4 yrs.	Sept	54	$275[3]	Dipl. or Degree
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Medical Department — U. S. Army — Medical Field Service School, Brooke Army Medical Center, San Antonio, Texas, and	James E. Tate, Lt. Col., M.C. Agnes P. Snyder, Major, WMSC.	h	12[13]	Nov.	20	None	See Below
Fitzsimons General Hospital, Denver, Colorado or	Harold B. Luscombe, Col., M.C. Olena M. Cole, Capt., WMSC.	Completion MFSS	12[13]	June	10	None	Certificate
Walter Reed General Hospital, Army Medical Center, Washington, D. C.	John H. Kuitert, Colonel, M.C. Barbara Robertson, Capt., WMSC.	Completion MFSS	12[13]	June	10	None	Certificate
Permanente School of Physical Therapy, Oakland, Calif.	O. Leonard Huddleston, M.D. Miss Dorothy Hoag	a-b-d	12 mos.	July	30	$200	Certificate
Cleveland Clinic Hospital, Cleveland, Ohio	Shelby G. Gamble, M.D. Miss Anna Wetterhuus	a-b-d	12 mos.	July	12	$200	Diploma

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2. R.N. plus one year college.
3. Nonresidents charged additional fee.
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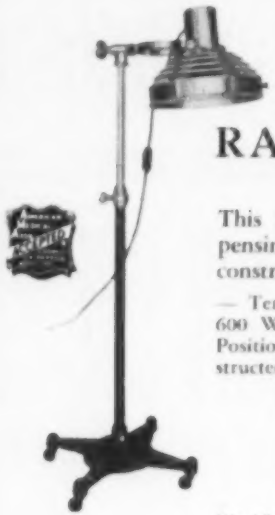
Council on Medical Education and Hospitals of the American Medical Association

NOTE: The duration of the course is expressed in academic years.

Name and Location of School	College Affiliation	Duration of Course	Classes Start	Entrance Requirements	Tuition Per Year	Certificate, Diploma	Graduates in 1947
University of Southern California, 923½ 35th Place, Los Angeles	University of Southern California	2 yrs.	FebSept	Degree	$420	Certificate	22
		5 yrs.	FebSept	High sch.	$450	Cert.&B.S.	
Mills College, Oakland, Calif.	Mills College	3 yrs.	FebSept	Degree	$200	Certificate	....
					$550		
San Jose State College, San Jose, Calif.	San Jose State College	1½ yrs.	Varies	Degree	$ 21	Certificate	10
		3¼ yrs.	Varies	High sch.	$ 21	Degree	
University of Illinois College of Medicine, 1853 W. Polk St., Chicago	University of Illinois	5 yrs.	Feb	High sch.	$152	B.S.	14
University of Iowa, Iowa City, Iowa	State University of Iowa, College of Medicine	5 yrs.	.....	High sch.	$ 85	Cert.&Deg	
University of Kansas, Lawrence	University of Kansas	2 yrs.	FebSept	Degree	$131	Certificate	10
		4 yrs.	FebSept	High sch.	$131	B.S.	
Boston School of Occupational Therapy, 7 Harcourt St., Boston	Tufts College	2 yrs.	Sept	Degree	$500	Diploma	13
		5 yrs.	Sept	High sch.	$450	B.S.	
Wayne University, 4841 Cass, Detroit, Mich.	Wayne University, College of Med., Coll. of Liberal Arts, Coll. of Education	5 yrs.	.....	High sch.	.....	.....	
Kalamazoo School of Occupational Therapy, Western Michigan College of Education, Kalamazoo	Western Michigan College of Education	1½ yrs.	FebSept	Degree	$127	Diploma	20
		4 yrs.	FebSept	1 yr. coll.	$127	Degree	
Michigan State Normal College, Ypsilanti	University of Michigan	5 yrs.	Varies	High sch.	$118	Cert.&Deg.	8
University of Minnesota, Church Street, Minneapolis	University of Minnesota	4 yrs.	.....	High sch.	$360	B.S.	
College of St. Catherine, St. Paul, Minn.	The College of St. Catherine	3½ yrs.	Varies	1 yr. coll.	$210	Degree	4
Washington University School of Medicine, St. Louis	Washington University	3 yrs.	Sept	2 yrs. coll.	$400	Degree	10
University of New Hampshire, Durham	Univ. of New Hampshire	5 yrs.	Sept	High sch.	$160	Cert.&Deg.	6
Columbia University College of Physicians and Surgeons, 630 W. 168th St., New York City	Columbia University	1½ yrs.	Sept	Degree	$450	Certificate	28
		2½ yrs.	Sept	2 yrs. coll.	$450	Degree	
New York University School of Education, 100 Washington Sq. E., New York City	New York University	4½ yrs.	FebSept	High sch.	$500	Cert.&Deg.	20
Ohio State University, Columbus	Ohio State University	3 yrs.	Quarterly	High sch.	$105	Degree	21
Philadelphia School of Occupational Therapy, 419 S. 19th St., Philadelphia	University of Pennsylvania	1½ yrs.	Sept	Degree	$500	Diploma	35
		3 yrs.	Sept	1 yr. coll.	$500	Diploma	
		.....	.....	High sch.	$600	.....	
Texas State College for Women, Denton, Tex.	Texas State College for Women	5 yrs.	FebSept	High sch.	$150	Degree	13
Richmond Professional Institute, 901 W. Franklin St., Richmond, Va.	Medical College of Virginia	1½ yrs.	Sept	Degree	$200	Certificate	20
		3 yrs.	Sept	1 yr. coll.	$200	Certificate	
College of Puget Sound, Tacoma, Wash.	College of Puget Sound	3 yrs.	FebSept	Degree	$350	Certificate	
		5 yrs.	FebSept	High sch.	$300	Cert.&Deg.	
University of Wisconsin, Madison	University of Wisconsin	4 yrs.	FebSept	High sch.	$320	Cert.&Deg.	8
Milwaukee-Downer College, Dept. of Occupational Therapy, 2512 E. Hartford, Milwaukee	Milwaukee-Downer College	2½ yrs.	Sept	1 yr. coll.	$300	Diploma	22
		4 yrs.	Sept	High sch.	$300	Dipl.&Deg.	
Mount Mary College, 2900 Menomonee River Dr., Milwaukee		Varies	Sept	Degree	$335	Certificate	15
University of Toronto, Dept. of University Extension, Toronto, Ont., Canada	University of Toronto	5 yrs.	Sept	High sch.	$260	B.S.Deg.	
		3 yrs.	Sept	1 yr. coll.	$222	Diploma	110
Colorado Agricultural and Mechanical College, Fort Collins, Colorado		5 yrs.	Sept	High sch.	.....	B.S.	



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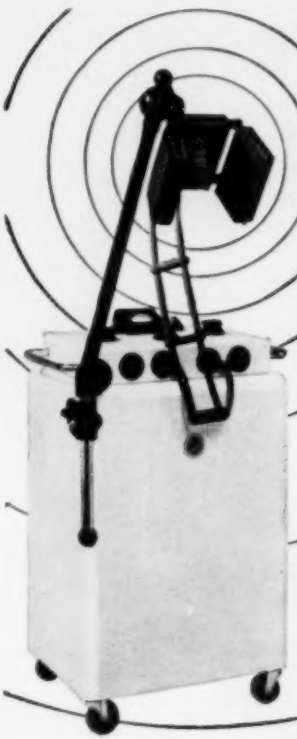

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